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CONCEPT DEFINITION OF A UNIT LOAD REARMING STATION FOR CARRIER-BASED AIRCRAFT

PREPARED FOR
NAVAL AIR DEVELOPMENT CENTER
WARMINSTER, PENNSYLVANIA 18974

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Concepts are defined for a unit load rearming station for carrier-based aircraft. Rearming station configurations are presented, subsystem hardware items are described, and operational analyses performed for a baseline rearming station.

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CONCEPT DEFINITION OF A UNIT LOAD

REARMING STATION FOR CARRIER-BASED AIRCRAFT

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I. INTRODUCTION

With the increasing emphasis on reducing military costs, it is of paramount importance that methods of doing day-to-day tasks be given close scrutiny. For example, for each one-man reduction in Naval personnel, approximately $15,000 is saved yearly, based on Chief of Naval Operations (CNO) estimates. Therefore, the reduction of personnel offers a sizeable cost saving potential. Of course, there is a limit to the amount of manpower reduction which can be tolerated before the work force efficiency is affected. This is especially true in the military where one man has many duties and responsibilities and eliminating the requirement for his services on one task may not eliminate the requirement for the man.

On the aircraft carrier, many of the flight operations tasks are performed manually simply because there is not available space or time to use mechanical equipment or automated systems. Specifically, the rearming of aircraft aboard carriers has for many years been, and continues to be primarily a manual operation. Mobile weapons loaders, although fine for use at shore based installations, are much less useful on a carrier deck, where rearming space is scarce and rearming time is precious.

This study defines a unit load rearming station which will greatly improve the rearming operations by reducing personnel, decreasing

rearming time, increasing the tonnage of weapons loaded per unit time, and enhancing safety.

The objective of this study is to define hardware concepts for a unit load rearming station. Specifically, the following objectives have been achieved:

- Selection and definition of the best system for aircraft/weapons alignment and aircraft suspension.
- Determination of strike-up and weapons pallet requirements.
- Development of concepts for a unit load rearming station consistent with present and planned Navy programs.

The rearming station defined as a baseline involves the positioning of an aircraft over a flight deck opening, positioning the weapons load on an elevator, and raising and latching the total weapons load as a unit. Systems hardware concepts are defined for the baseline and operational investigations made to predict manpower and time requirements.

II. SUMMARY

During a previous study, reference 1, Chrysler Corporation determined the feasibility of a unit load rearming concept for carrier-based aircraft. In this study, system hardware concepts are generated for a unit load rearming station compatible with present and future ship design. The concepts presented involve the simultaneous raising, mating and latching of the aircraft's total weapons load or any portion of the total load as opposed to a singular, manual attachment of weapons. Rearming station configurations are presented, subsystem hardware items are described and an operational investigation is performed for the baseline rearming station.

The study consists of four major tasks: selection of alignment and suspension concepts, definition of concepts, analysis of strike-up and weapons pallet make-up concepts, and generation of system hardware concepts.

Selection of alignment and suspension concepts involve the analysis of aircraft support and weapons/aircraft alignment systems and the determination of the most promising concepts. An aircraft support concept using two adjustable main gear support beams and a nose gear bridge to position and secure the aircraft over the rearming station is selected. A weapons alignment concept involving the alignment of a

weapons pallet and aircraft to a common reference datum is selected for aircraft/weapons alignment.

In the development of the rearming station concepts, three major configurations are presented. The concepts range from a very basic to an automated concept, representing the ultimate goal for rearming carrier-based aircraft. The baseline concept selected for system development lies between these two extremes. Subsystem concepts for supporting the baseline rearming station are defined and operational investigation results are presented.

The analysis of strike-up and weapons pallet make-up determines the requirements for ordnance strike-up to feed the rearming station and for a weapons pallet design to position, secure, align and move the unit weapons load from the make-up area to the aircraft.

Based upon the requirements for unit load rearming, system hardware concepts are generated for the baseline rearming station and the availability of off-the-shelf hardware is discussed. An in-depth investigation of the physical size, weight and configuration of major subsystems of the baseline rearming station is presented. Physical and operational problems are identified and concepts for eliminating these problems are outlined.

III. CONCLUSIONS

The development of a unit load rearming station for carrier-based aircraft is feasible and well within the present state-of-the-art. Many of the hardware items associated with the unit load rearming station are currently available and those items not in the off-the-shelf category will require a minimum development time.

The final phase of weapons attachment may require a mechanical alignment device similar to the pin and cone technique presented herein. At this point, it is concluded that this requirement cannot be determined by further analytical study, but should be demonstrated with functional models of the rearming station and mock-up (or actual) aircraft.

A relief in the close tolerances between the suspension lugs and the ejector bomb rack hooks will drastically reduce the complexity of mating and latching the unit weapons load to the aircraft and, depending upon the degree of relief, may eliminate the requirement for a final alignment correction. Again, this will necessitate investigations with actual or simulated hardware to provide data on which to base a decision.

The baseline concept (two-pass concept) is the most promising concept for the unit load rearming station. This concept rearms the F-4 aircraft by loading the forward weapons stations, moving the aircraft forward approximately 10 feet and loading the aft weapon stations,

thus the "two-pass" connotation. The ship volume required for the two-pass concept is reduced approximately 30% over the single-pass station concept.

Operational analysis results indicate that use of the baseline unit load rearming station can significantly increase aircraft carrier safety by greatly reducing congestion of loading equipment and personnel on the flight deck. The rearming station offers a better combination of man and machines, a possibility of improving the existing attack aircraft carrier's (CVA) capability and a reduction of ordnance loading personnel. Rearming aircraft of the same type can be accomplished with the baseline station in 3 1/2 minutes per aircraft, utilizing 25 men on the flight deck and 14 men below deck.

IV. RECOMMENDATIONS

It is recommended that critical hardware systems (full size and functional) of the unit load rearming station be designed and fabricated, and tests performed to evaluate critical facets of the station as follows:

- Determine if the weapons and aircraft can be aligned to an a accuracy which will eliminate the need for final alignment on the flight deck.
- Determine the effects of aircraft variables, such as tire pressure, structural deflections, fuel load, etc., on unit load alignment and mating.
- Determine the feasibility of using a pin and cone final alignment technique, if required.
- Perform simulated weapons loading to provide data for operational analyses and to validate clearance requirements.

It is recommended that a rugged, functional model (approximately 1/10 scale) of the baseline rearming station be built to better define overall operations, hardware design and equipment flow.

In addition, it is recommended that the following specific studies be initiated:

- Rearming Station for Sea Control Ship - Analyze the requirements and generate a rearming station design for an advanced

air capable ship similar to the Sea Control Ship (SCS). This design will be less complex than for the CVA ships since the tempo of operations will not require a very fast turnaround rate, the aircraft complement is much less, and only one, or possibly two, types of aircraft will be stationed on the SCS.

- Turnaround Station Concept - Determine the feasibility and desirability of incorporating other aircraft turnaround functions into the rearming station to provide total aircraft servicing, such as proposed by the "one-stop" servicing concept.
- Weapons Rack/Suspension Concepts - Generate designs for a universal suspension lug/ejector bomb rack system which will eliminate the requirements for, or automate the use of, safety pins, ejection cartridges, sway braces, and electrical connections. The design should provide sufficient mating clearances between the suspension lug and EBR hook to enable a more efficient use of present weapons loading equipment and to reduce the problems of automating weapons loading.

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IV. REPORT TEXT

A. SELECTION OF ALIGNMENT AND SUSPENSION CONCEPT

1. Introduction

Concepts, formulated during a previous Chrysler study, reference 1, to:

- Support the aircraft over the rearming station and
- Align the aircraft and weapons pallet

were analyzed and the best concepts selected. In addition to reference 1, study results from associated studies reference 2 through 6 were used in establishing operational guidelines. In order that the selection be based not only on the suspension and alignment functions but also on the aircraft and ship interfaces, an operational analysis and numerical rating technique was used.

2. Aircraft Suspension Concept Comparison

Figure A-1 in Appendix I of this report is a comparison matrix of three aircraft suspension concepts, the column support, the guide rail support and the extendible beams and bridge support. Their major operational features, advantages and disadvantages are discussed below.

a. Column Support

The operational features of the column support are as follows: The rearming station elevator is in the up position when

the aircraft is moved into and out-of the loading station by a tow truck. For loading, the nose gear wheel is positioned and secured outside the elevator area. The main wheels are positioned and locked onto the support columns. The rearming station elevator is lowered around the stationary support columns to shuttle the unit loader to and from the flight deck level. The aircraft remains hooked to the tow truck during the total ordnance loading operation. No unhooking and rehooking of the tow truck is necessary.

The two support columns are anchored below the 03 level on guide rails. The columns are moved on the guide rails and locked into position to correspond to the A-4, A-6, A-7 and F-4 main wheel tracks. The columns telescope sufficiently to permit them to be moved from one location to another when the rearming station elevator is raised to the flight deck level. Locking mechanisms accurately stop-and-lock the columns at preset positions corresponding to the aircraft gear location. Manhole covers lock into the rearming station elevator at unused column positions to provide a smooth continuous elevator surface.

b. Guide Rail Support

The corresponding operational features of the guide rail support system are as follows: The aircraft main wheels are supported by two, deck level, rails which span the rearming station elevator opening. The nose gear is supported by a movable cross

member. The aircraft is moved into and out of the loading station independent of the rearming station elevator position.

The guide rails rest on low friction bearings and are moved and locked into position to correspond to the various aircraft main wheel tracks. The rails are equipped with wheel guides which assure that a wheel is centered on the rail. The cross member locks to the nose gear wheel and moves with the aircraft along the guide rails to a preset position. After ordnance loading the cross member carries the nose gear wheel outside the rearming station elevator opening. The aircraft is moved into and out of the loading station by a positioning endless chain which engages the aircraft nose gear. Analysis show that the guide rail system requires one less elevator cycle per loading sequence than the column support system. Consequently, the rearming station elevator is available for a longer time at the 03 level as compared to the column support concept.

c. Extendible Beams and Bridge Support

The major operational features of the extendible beams and bridge support system are as follows: The aircraft nose gear is supported by a bridge, while the main gear wheels are supported by extendible beams during aircraft positioning and weapons loading, and by the bridge during the movement of the aircraft out of the station. The aircraft is moved into and out of the loading station independent of the rearming station elevator position.

The operational sequence is as follows: The bridge is in the aft position and the extendible beams are adjusted to the aircraft main gear wheel pattern. The nose gear wheel is moved onto and fixed to the bridge. The bridge moves forward, moving the aircraft, until main gear wheels come to rest against stops on extendible beams. The bridge assembly and extendible beams move forward until the aircraft is positioned in a predetermined station. During the above operation the wheels are secured and locked to the beams and to the bridge assembly. The bridge assembly unlocks from the nose gear wheel and moves aft to make contact with extendible beams, locks onto the main gear support pads and moves the aircraft out of the loading station. This aircraft support system offers the same "independent of elevator" advantages as the guide rail support concept; however, the system requires synchronization of support beams and the bridge assembly movements, has more moving parts and is more complex to operate.

d. Comparison Matrix

The numbers in the body of Figure A-1, in Appendix I, are concept data and concept rating information. The left hand column is a tabulation of important aircraft support features. The importance of the system feature to the overall loading station concept is the weighting factor (IR). This value, IR, is multiplied by the concept "rating" number and summed to give a total concept comparison.

The highest score indicates the most desirable concept. The numerical values of the weighting factors and concept rating are based upon engineering judgment to a large degree. These values were jointly agreed upon by Chrysler and Navy personnel.

The guide rail support concept received a low structural weight rating since its estimated weight is approximately 3,000 pounds more than either of the other two concepts.

System simplicity, which is indicative of low developmental and operational cost and low operational skill requirements, is given a high IR rating. The extendible beam and bridge support concept is considered significantly more complex to design, operate and service because of the large number of sliding support members and the requirement for synchronized movement of the extendible beams and bridge assembly. The column support system is rated slightly higher for normal operation and safety because the aircraft can be moved across a solid elevator floor in lieu of across rails over an elevator opening. Also, this concept has minimum obstructions as the weapons are moved upward to mate with the aircraft. However, this advantage is nearly offset by the fact that the columns do interfere with the movement of the pallet onto the elevator.

The column support concept was judged less vulnerable to flight deck accident because the majority of the support assembly is

below the flight deck. Also, the column support concept is considered slightly safer to operate because this concept does not contain structure overhanging the rearming elevator as the elevator is raised.

The inherent reliability of the extendible beam and bridge support is rated lower than the other two concepts because of the increased mechanical complexity and the required electrical interlocks for synchronization of the support beam and bridge movements.

As discussed in the following section, the column support concept requires more time to complete an aircraft loading cycle because of the extra cycle required by the elevator. No significant difference exists in required manpower to operate a station using either of the three aircraft suspension concepts.

Operational analysis of the three concepts indicate that the column support system is less subject to system automation. Also, the impact of the column support concept hardware on ship design appears to be less desirable. For example, a change of the loading station to accommodate a new aircraft would require extensive modifications to the elevator and ordnance pallet because of the holes required for the support columns. On the other hand, the guide rail support system could easily be adjusted to accommodate new aircraft or weapon support hardware.

e. Operational Analysis

Figure A-2 is a flow process chart which compares the operational sequence of aircraft during ordnance loading using the three aircraft support concepts. The interdependent sequence of the unit loader, elevator and aircraft are outlined. The significantly different operations are: 1) the extra elevator cycle required with the column support system, and 2) the tow truck unhooking and hooking operations with the other two concepts.

A comparison of the required ordnance loading time and manpower was made for each of the three candidate aircraft support concepts. Care was exercised to maintain consistent ground rule and input data. Crew make up, work stations layout and general assumptions are consistent with those used in reference 1. Multiple Activity Charts, figures A-3 and A-4, are based upon one loading station per ship. Nominal loading of the A-7 aircraft is assumed. The time required for each individual operation is based upon conservative estimates of manpower and hardware movements.

Figure A-3 is a multiple activity chart for a typical rearming operation using the unit loader and the column support concept. Figure A-4 presents a similar chart for comparative purposes of rearming operation using the unit loader and the rail or extendible beam and bridge support system (the other two alternatives). Comparison of figures A-3 and A-4 indicates that the

column support system results in slightly slower aircraft loading (3.5 minutes versus 3.0 minutes for the other two concepts). This slower time results from the requirement that the elevator be at the flight deck level for moving aircraft into and out of the loading station. While the rearming station elevator is at flight deck level the 03 level operations are delayed.

f. Concept Selection

The guide rail support was selected as the best support concept based upon results from the operational analysis and the concept comparison matrix. Even though the total numerical rating of the guide rail concept and the column support concept was almost equal, it was mutually agreed that the guide rail concept offered less design risk, greater system improvement potential and significantly less impact on associated systems.

3. Alignment Concept Comparison

Figure A-5 is a comparison of the eight alignment concepts defined in Chrysler Report HGS-R52-70, Ref. 1. The concepts fall into three categories: mechanical/forced, semiautomatic/manually controlled and automatic/sensor controlled; each concept has inherent strong and weak points which are tabulated. One of the most important characteristics of an alignment concept is the number of tolerance build up stations. An alignment concept is most desirable which: has a minimum number of tolerance build up stations, the smallest misalignment per

station; is simple, reliable, easy to automate and: has a low potential of damaging the aircraft.

Since concepts for aligning the ordnance and aircraft fall into three general categories a comparison of these three categories was made. Figure A-6 is a numerical rating matrix of general concepts for gross alignment of aircraft and ordnance. The highest score indicates the most desirable concept. Operational evaluation and numerical rating indicate that, for the aircraft carrier environment, the automated/sensor controlled alignment concept is more complex, more difficult to maintain, and has a lower inherent reliability. The forced alignment concept using pin and cone has a high simplicity, is inherently rugged and easy to maintain. However, the forced alignment concept has a limited degree of operational flexibility. That is, readjustment is difficult once the pin and cone are mated. A semiautomated system, whereby fixed alignment/indexing points on the aircraft and ordnance are aligned to corresponding index points receive higher overall numerical rating. These numerical rating values are based upon engineering judgment and were selected in a joint meeting of Chrysler and Navy personnel.

Analysis results indicate that an alignment system which uses pins and cones, forced alignment, as a primary system and a semiautomated technique for alignment verification or final alignment would be optimum. Based upon concept comparison results a semiautomated

alignment concept which incorporates forced alignment features was selected for further development. As a first step a baseline alignment concept was formulated based upon the strong points of the eight Chrysler concepts. The baseline alignment system, included in Appendix I of this report, has the following attractive features.

- Danger to aircraft is low
- Concept is easy to automate
- The misalignment tolerance build-up is low
- The unit loader is not required to be at flight deck level and therefore is free for 03 level activity
- No complicated electro-optical hardware is required

B. DEVELOPMENT OF CONCEPTS

1. CVA Rearming Stations

a. General Definition of Major Concepts

During the course of the present study, it became evident that several concepts were available for performing the aircraft rearming aboard CVA-type ships. All the concepts are basically the same, i.e., each requires the suspension of the aircraft over a deck opening and the positioning, raising, and latching of the weapons by means of a lift or elevator. The major differences in the concepts are the degree to which the concept has been automated, the flexibility, reliability and versatility designed into the concept, and the extent of modifications to the ship for implementation. At

least three concepts for a rearming station have been identified and analyzed during this study. Other concepts, which may be a combination of features from two or more of the three have been studied, but it appears that the three concepts are generally the most representative.

The major features of the three concepts are discussed, the strong and weak points of each are identified. A matrix of concept features is presented for summarization and comparison of the concepts.

(1) Concept I. "BASIC" Concept

Description: The basic concept consists of a rearming station built in modules for new ship construction and for possible backfitting with minimum ship modifications. The modules contain all the equipment and hardware required for accepting the weapons at the make-up area and delivering them to the aircraft. The aircraft support system is the main gear support beams and nose gear bridge, and the aircraft is moved on and off the station by the nose gear bridge. The weapons load is made-up on the ordnance elevator which is used to raise the positioned and aligned weapons to the aircraft.

Major Features:

- Two-pass loading of F-4 aircraft (see Section V-B.2.a).

- Deck opening and rearming station elevator sized for the largest unit load.
- Unit load make-up is performed on the rearming station elevator.
- Modular construction of station allows for smoother implementation on new ships and minimizes modification in backfitting.
- Aircraft support is by main gear beams and nose gear bridge. The nose gear bridge is used to position aircraft over the station.
- Weapons support fixtures, providing the capability of adjustment in three directions, and pitch, roll, and yaw angles, are mounted on rails and positioned manually.
- Weapons are manually aligned on the flight deck via the weapons support fixtures.

Assessment: The basic concept is capable of rearming an aircraft in approximately 7 minutes. This requires a minimum of two stations to achieve the desired turnaround rate of 17 aircraft per hour (reference 7). The main reason for the 7-minute time is because the rearming station elevator and the ordnance elevator must function dependently. The rearming station elevator cannot be used during unit load make-up.

Another factor is that the empty skids from the previous aircraft must be cycled to the main deck before the next aircraft load can be prepared.

With the basic concept, the deck opening and elevator are sized for the unit load so that once the weapons are positioned on the elevator for loading they need not be moved. The basic concept offers better control of weapons flow. requires less manual labor and provides more efficient rearming than present loading procedures.

The modular type construction should decrease yard time for implementation on either new ships or backfitting since the rearming stat on could be constructed, equipped and checked out prior to installation on the ship.

(2) Concept II. Baseline Concept

Description: The baseline concept is a refinement of the basic concept to meet the desired turnaround times, to reduce personnel requirements, particularly on the flight deck, and to eliminate manual handling of weapons. This concept represents the minimum system for efficiently and safely performing unit load rearming. The station utilizes a weapons pallet to support the weapons and to shuttle the unit load from the make-up area to the ordnance loading elevator. Two unit load make-up areas are provided at two deck levels to speed

the loading process. A weapons alignment fixture is used to align the weapons on the weapons-pallet so that the weapons lugs coincide with the ejector bomb rack (EBR) hook location.

Major Features:

- Two-pass loading for F-4 aircraft
- Deck opening and rearming station elevator sized for the largest unit load of weapons
- Two separate weapons pallet make-up areas located at two deck levels and adjacent to the rearming station elevator.
- A weapons pallet provided for each make-up area
- Aircraft support by main gear beams and nose gear bridge
- Modular construction decreases complexity for new ship implementation or backfitting.
- Weapons support fixtures mounted on low friction rail system enables fast, smooth positioning and positive braking and locking capability.
- Nose gear bridge used to position aircraft over rearming station
- Weapons alignment fixture permits the total weapons load to be positioned and aligned in the make-up area, reducing or eliminating the requirement for weapons alignment on the flight deck.

- The same weapons pallet is used for loading all stations of the A-4, A-6, A-7 and forward stations of the F-4, and the aft stations of the F-4 during two-pass loading.

(3) Concept III. "AUTOMATED" Concept

Description: The automated concept is a refinement of the baseline concept to incorporate more automation into the station. This concept has two weapons pallet make-up areas at two deck levels and uses a separate weapons pallet for each make-up area. Drive systems with remote controls provide the mobility for the weapons support fixtures. The adjustment system for the weapons support fixtures is also motorized and can be remotely actuated and controlled. The weapons are aligned with a computer controlled alignment fixture which accounts for various aircraft variables such as tire pressure, landing gear stiffness, fuel load and manufacturing tolerances.

The weapons pallet and rearming station elevator are designed in two sections to enable single pass loading of all aircraft. For all aircraft except the F-4, the forward pallet section and the forward elevator section are used for weapons loading. For the F-4, both pallet sections and both elevator sections are used.

Major Features:

- Single pass loading of all aircraft
- Deck opening and rearming station elevator sized to accommodate unit loading of the F-4 and similar aircraft.
- Two pallet make-up areas with one weapons pallet for each. Make-up areas at two deck levels.
- Dual rearming station elevator and two-section weapons pallet to more efficiently handle single-pass loading of all aircraft
- Motorized weapons support fixtures and weapons pallets to eliminate manual handling and positioning of ordnance
- Remotely actuated and controlled adjustments for the weapons support fixtures
- Computerized weapons alignment fixture for automatic set-up and alignment of weapons on the weapons pallet
- Aircraft support by main gear beams and nose gear bridge
- Weapons alignment accomplished in the make-up area. Hands-off loading on the flight deck.
- Modular construction of station.

Assessment: The automated concept, while requiring more ship volume than the other concepts, will greatly improve the efficiency of aircraft rearming. Manpower requirements will be reduced, safety enhanced, rearming reliability increased and turnaround time decreased. For new ship construction, the optimized rearming concept can be integrated with advanced strike-up and strike-down concepts and magazine storage and retrieval concepts to provide a completely automated weapons handling, movement and loading system from magazine to aircraft.

(4) Concept Comparison

The major features of the three concepts are summarized in table 1.

Table 1. Rearming Station Concept Comparison

Major Feature \ Concept	Basic	Baseline	Automated
1. Deck opening and rearming station elevator sized for two-pass loading	X	X	
2. Deck opening and rearming station elevator sized for single-pass loading			X
3. Unit load make-up on the rearming station elevator	X		
4. Two make-up areas at two deck levels		X	X
5. One weapons pallet (fixed to rearming station elevator)	X		

Table 1. Rearming Station Concept Comparison (Continued)

Major Feature \ Concept	Basic	Baseline	Automated
6. Two movable weapons pallets		X	X
7. Modular construction	X	X	X
8. Aircraft suspension by "main gear beams and nose gear bridge" concept	X	X	X
9. Single rearming station elevator	X	X	
10. Dual rearming station elevator			X
11. Weapon support fixtures positioned manually	X		
12. Weapon support fixtures positioned manually with aid of drive motors		X	
13. Weapon support fixtures automatically positioned by servo system			X
14. Final weapons alignment performed manually on flight deck	X		
15. Weapons alignment fixture in make-up area (reduces or eliminates final alignment on flight deck)		X	
16. Weapons alignment remotely controlled and automatically performed in make-up area			X

b. Development of Selected Concepts

The rearming station concepts selected for development are closely related to the three concepts described previously but incorporate some of the best features of all those studies. In the

early stage of the study, the one-pass system, similar to the "automated" concept, was developed. As this concept became more clearly defined and analyses were performed, the baseline concept evolved. Then as a further refinement, to reduce the deck opening size and the below deck volume required for the loading station, the basic concept was generated. The basic concept represents the minimum system which meets the requirements for unit loading. The baseline concept represents the preference, at this stage of total system development, for a unit load rearming system.

(1) One-Pass Rearming Technique

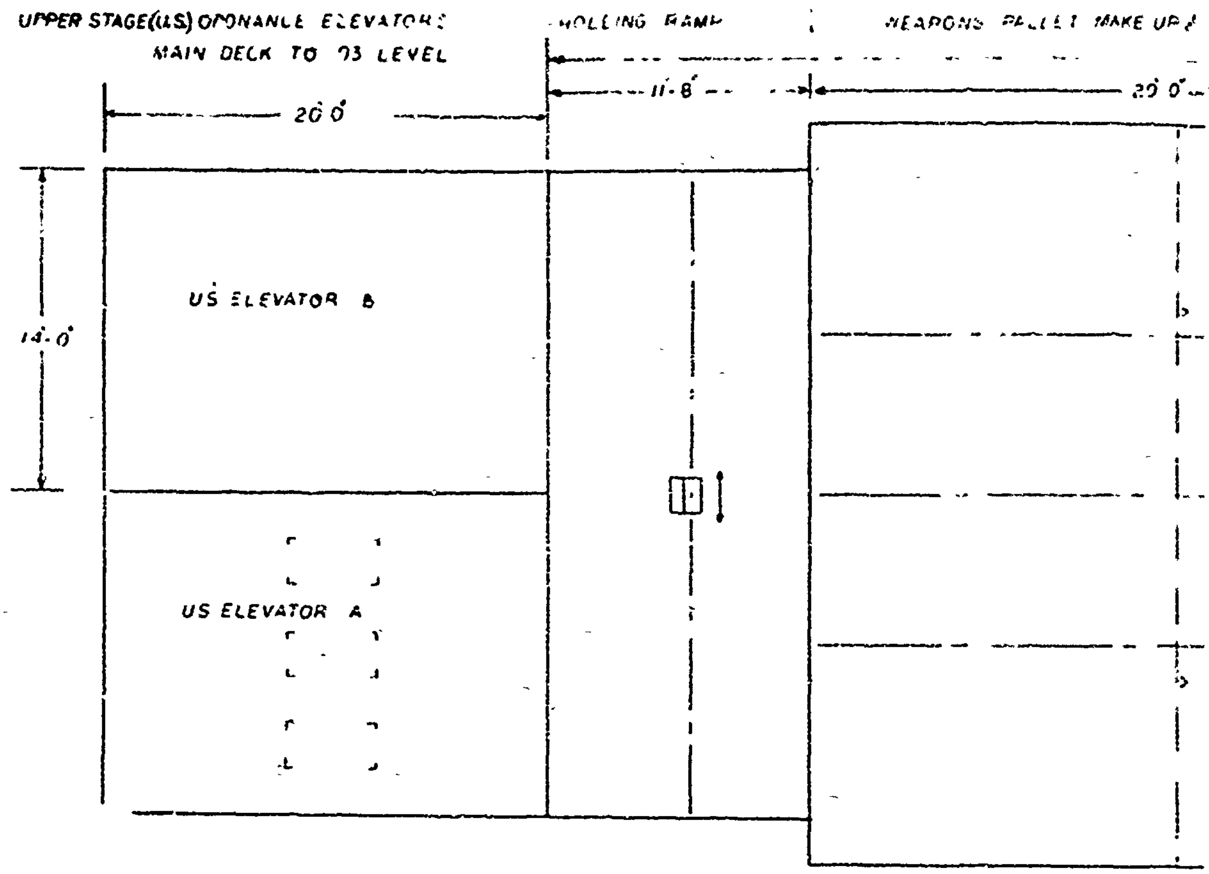
The one-pass rearming technique is capable of loading the total weapons load of the F-4, A-4, A-6 or A-7 aircraft with a single spotting over the rearming station. The deck opening has been sized for the largest unit load of weapons, carried by the largest aircraft. In this case, loading the F-4 aircraft with a 600-gallon fuel tank on the centerline weapon station and 6-MK-82 /MER on the outboard wing stations is the governing situation for station length. The width of the station opening is based on the width required to load the A-7 aircraft. The A-7 presents a special problem since the weapons loaded on the inboard wing stations must be moved laterally to clear the main landing gear, raised above the landing gear, and then moved laterally to mate and latch on the EBR. This lateral movement

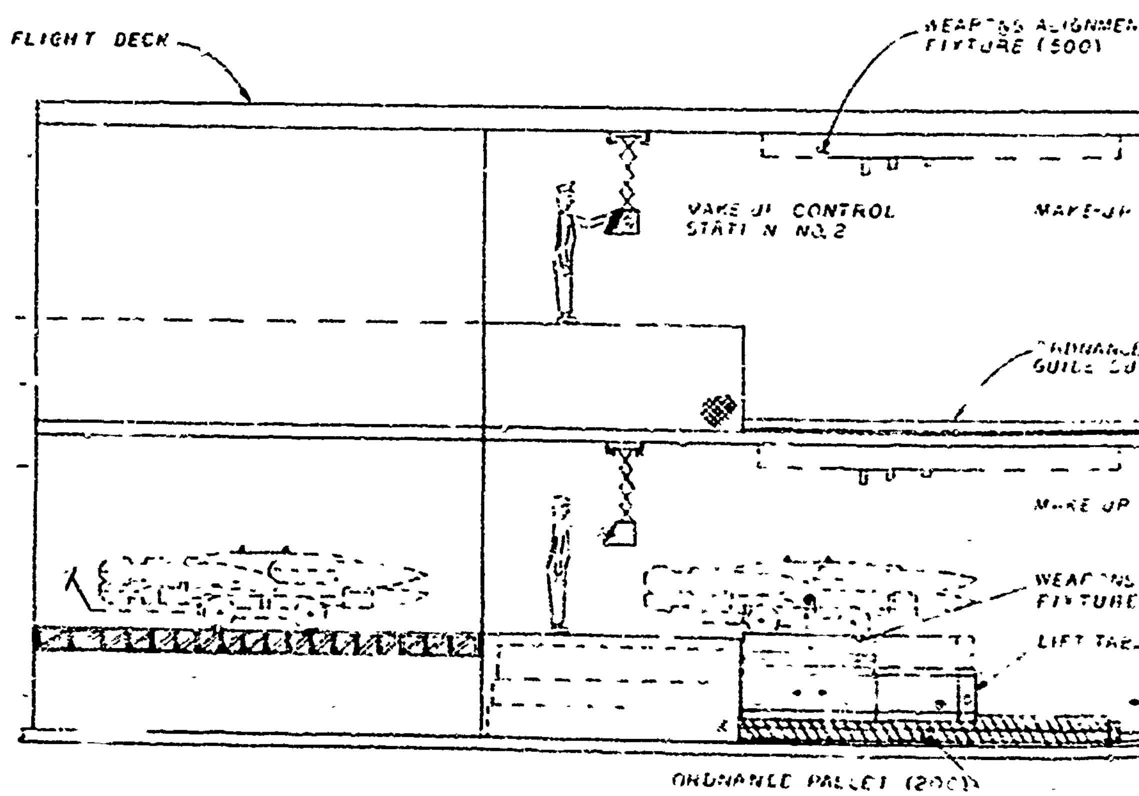
dictates the station opening width. The specialized case of A-7 weapons loading is treated in Section V-B.2.

The deck opening for one-pass loading was determined to be 32 feet wide by 38 1/2 feet long. Refer to figure 1. The below deck areas consist of the rearming station elevator, the weapons pallet make-up and alignment area, and the holding area. Two upper stage ordnance elevators feed the rearming station from magazines located at various ship levels. As seen in figure 1, the below deck space is divided into two bi-level areas. The bi-level design offers many advantages in time savings, orderly and efficient weapons and skid handling, and better control.

The upper stage ordnance elevators are capable of feeding either the upper or lower make-up level. Each elevator is sized to carry 3 of the largest ready service weapon/skid configurations. With two elevators, this enables the total weapons load for most aircraft to be brought to the make-up area with one elevator cycle. Other advantages of the dual elevators are discussed in detail in the operational analysis, Section V-E.

The holding ramp provides temporary storage of skids so that the ordnance elevators may be cycled. The holding ramp is sized to allow the longest weapon/skid to clear the ordnance


UPPER STAGE(U.S.) ORDNANCE ELEVATORS
MAIN DECK TO 03 LEVEL
ROLLING RAMP
WEAPONS PALLET MAKE UP
20'0"
11'-8"
20'0"
14'-0"
US ELEVATOR B
US ELEVATOR A


FLIGHT DECK
WEAPONS ALIGNMENT
FIXTURE (500)
MAKE UP CONTROL
STATION NO. 2
MAKE-UP
MAKE UP
LIFT TAB
ORDNANCE PALLET (200)

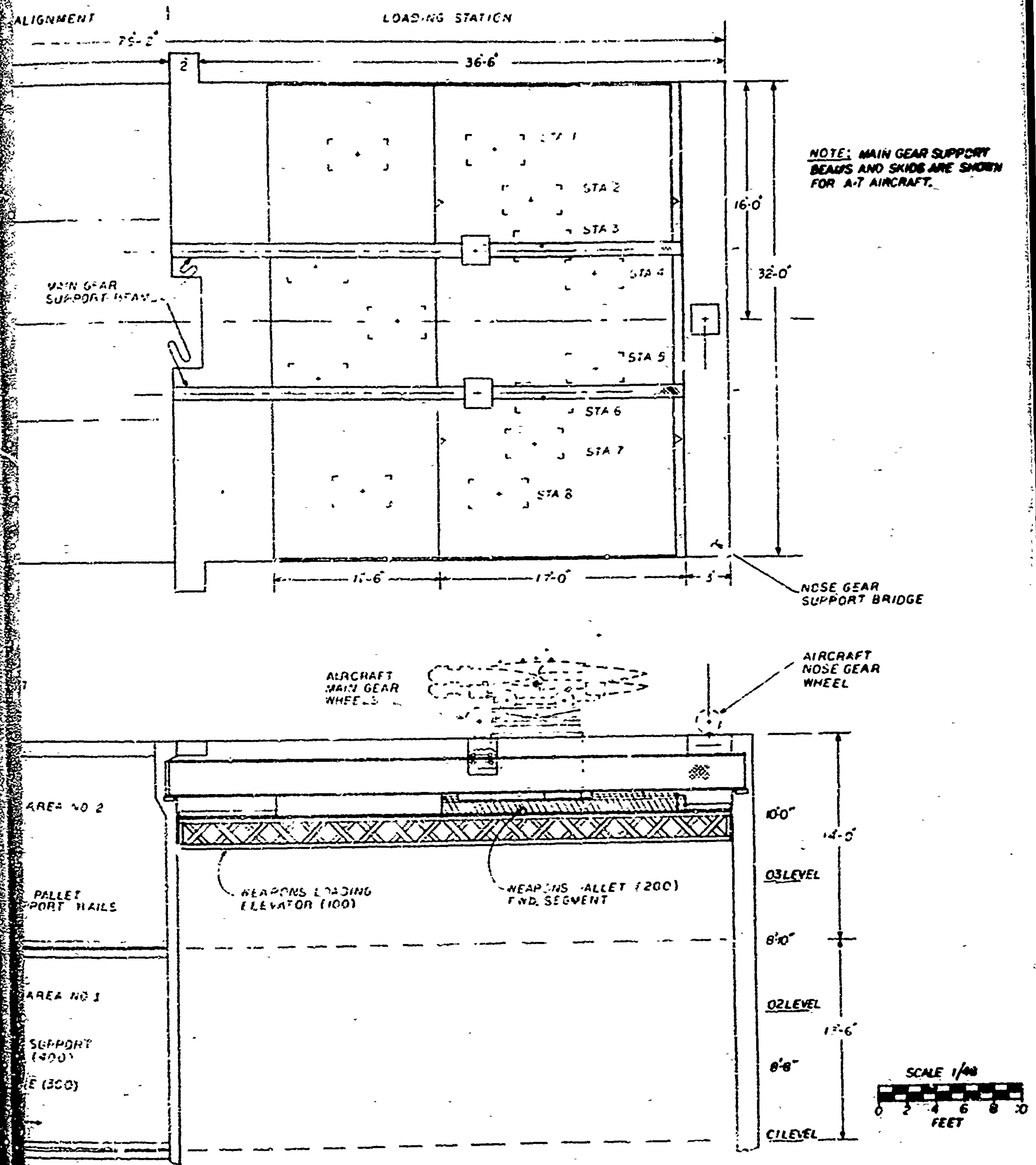


FIGURE 1, UNIT LOAD REARMING STATION - AUTOMATED CONCEPT

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elevator. Since the ordnance elevators service either the upper or lower make-up areas, the holding ramp permits the assembly of the aircraft weapons load at one make-up level while the weapons pallet is being prepared at the other level. These features not only provide independent operations, but provide a redundancy in the event of failure of one ordnance elevator or one make-up area.

The make-up areas are key components of the rearming station. In these areas, the weapon positioning and alignment on the weapons pallet is accomplished. The make-up area provides a parking space for the weapons pallet. The pallet is composed of two sections, a forward and aft section. The forward pallet section is used for loading the A-4, A-6, A-7 and the forward stations of the F-4 aircraft, and the aft pallet section is used exclusively for the F-4 aircraft. This approach has been used to avoid handling the total pallet except for the F-4 aircraft loading. The aft pallet section is stored beneath the holding ramp when not being used. Again, by providing two pallets and two make-up areas simultaneous operations can take place at both levels and redundancy is provided.

An alignment fixture, located in the make-up area, is used to accurately and quickly align the weapons on the weapons pallet. The pallet is then aligned with respect to the aircraft on

the rearming station elevator to complete the gross alignment. Final weapons lug and ejector bomb rack hook alignment, if required, is accomplished on the flight deck.

The rearming station elevator shuttles the weapons pallet to and from the flight deck level. The elevator is designed to support and lift the total pallet (forward and aft sections) and weapons load to the aircraft. The idea of using a separate elevator for each pallet section was considered but discarded since the problems of synchronizing the two would be difficult to overcome and very little, if any, weight savings could be realized. Therefore, the rearming station elevator is sized to lift the total F-4 weapons load, using both pallet sections.

The rearming station elevator can serve either of the two make-up levels. This enables simultaneous operations to take pl :e in the make-up areas and provides versatility to the total system.

The aircraft is supported and positioned over the station by two main gear support beams and a nose gear bridge. The main gear support beams span the deck opening longitudinally and carry the main gear pads which support and secure the aircraft main gear during movement and weapons loading. The beams and nose gear bridge have been preliminarily sized and analyzed for sin k loading. The calculations may be found

in Appendix III. The depth of the main gear support beams is approximately 30 inches and the nose gear bridge is approximately 16 inches deep. Allowing 2 inches for detailing the beam connections, a total of 48" is required for aircraft support structure. This distance becomes a controlling dimension for the design of the weapons loading elevator, pallet and weapons support fixtures since the top of the pallet must be 48" below the flight deck level.

(2) Two-Pass Rearming Technique (Baseline)

The two-pass loading technique is shown in figure 2. Comparing the two-pass technique with the single pass technique shown in figure 1, the following differences are noted:

- Deck opening has been reduced from 32 feet x 38 1/2 feet to 32 feet x 28 3/4 feet
- Below deck space has been reduced. The make-up areas are 17 1/2 feet x 32 feet compared to 29 feet x 32 feet for the single pass concept. The holding area and upper stage elevator size is unchanged.
- One pallet section, 31 1/2 feet x 16 1/2 feet is used to load all aircraft.
- Total station volume is reduced approximately 31%.
- The elevator length has been reduced from 38 1/2 feet to 28 3/4 feet. The width (32 feet) remains the same.

A

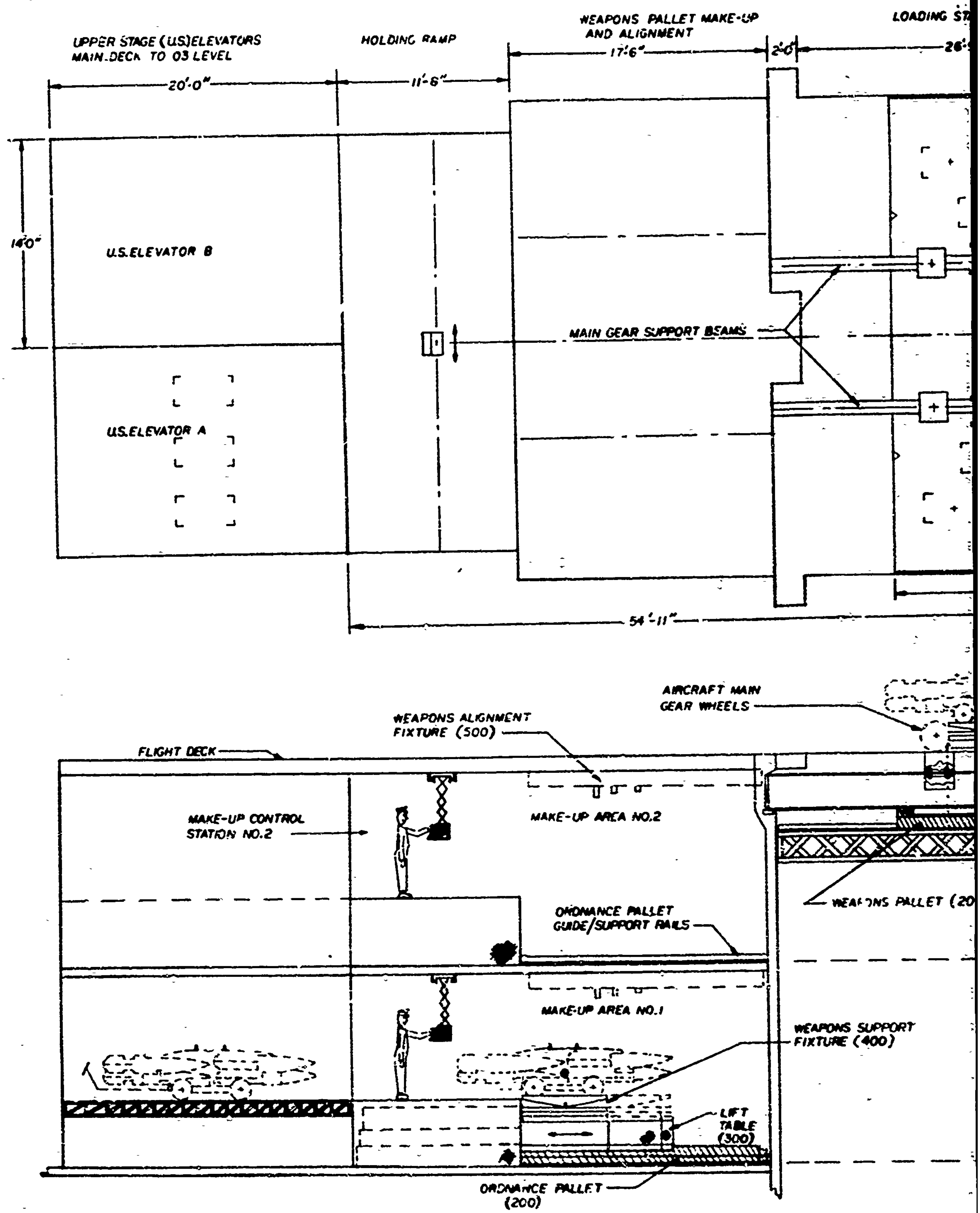


FIGURE 2, UNIT I

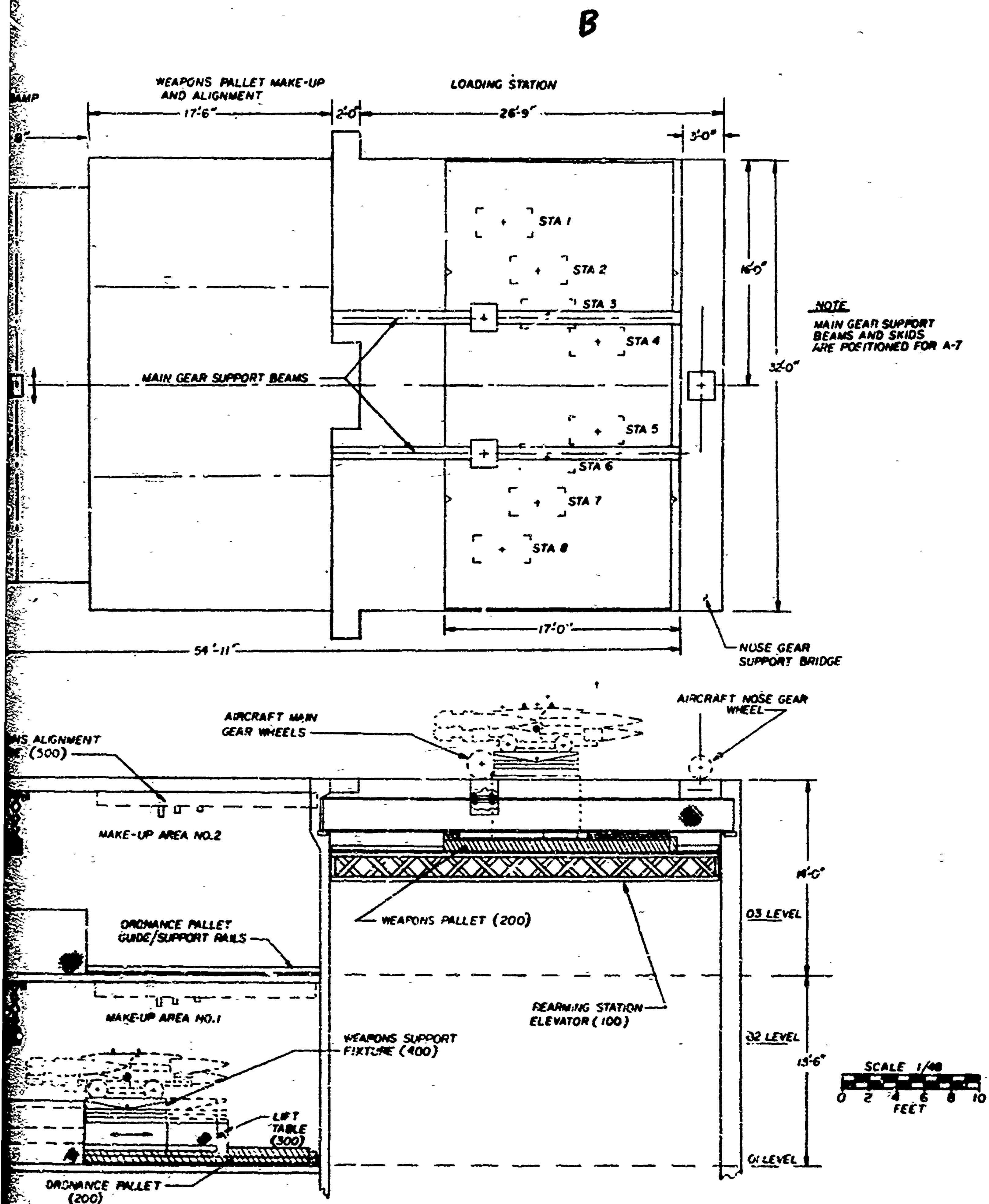


FIGURE 2, UNIT LOAD REARMING STATION - BASELINE CONCEPT

Although the elevator size for the two-pass technique can be reduced to approximately 17 feet x 32 feet, it was decided to leave the elevator the same size as the deck opening in order to completely close the deck opening when the station is not in use.

Comparison of operational features, such as loading time and manpower, are given in Section V-E for the single pass and two-pass techniques.

(3) Basic Concept

The basic concept is shown in figure 3. This concept utilizes the rearming station elevator for unit load make-up and alignment and has a single upper stage (U.) ordnance elevator. The weapon support fixtures are rail supported and have the capability of longitudinal and lateral movement. The concept does not have a movable weapons pallet as in the previous concepts, but uses the rearming station elevator as a fixed weapons pallet. These factors influence the operational sequence of the rearming station to a great degree, since they necessitate upper stage ordnance elevator and rearming station elevator cycling dependency.

The U.S. ordnance elevator is 28 feet x 20.5 feet and will carry six fully loaded weapons skids, the maximum required for two-pass loading. With the basic concept, the aircraft's

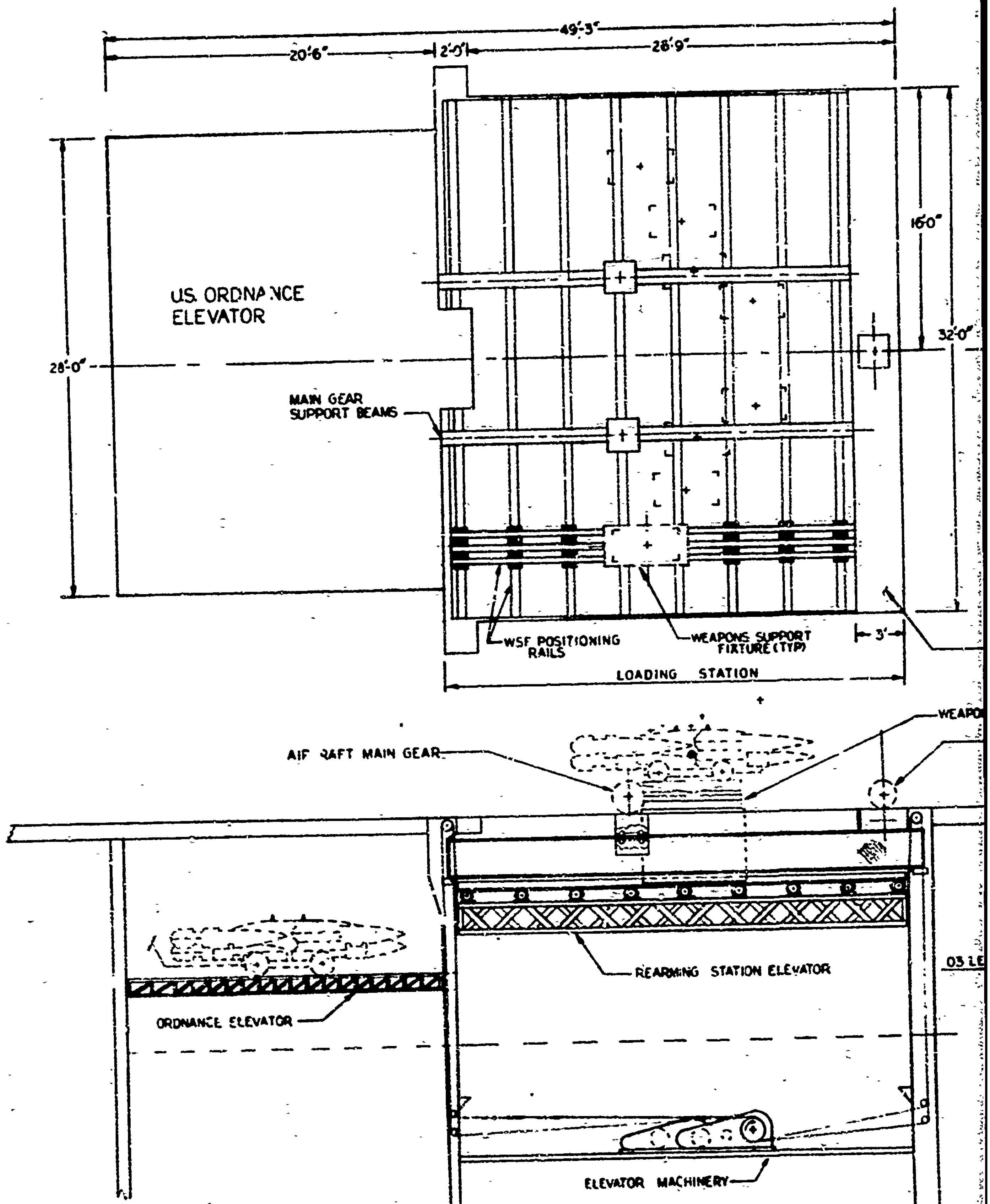
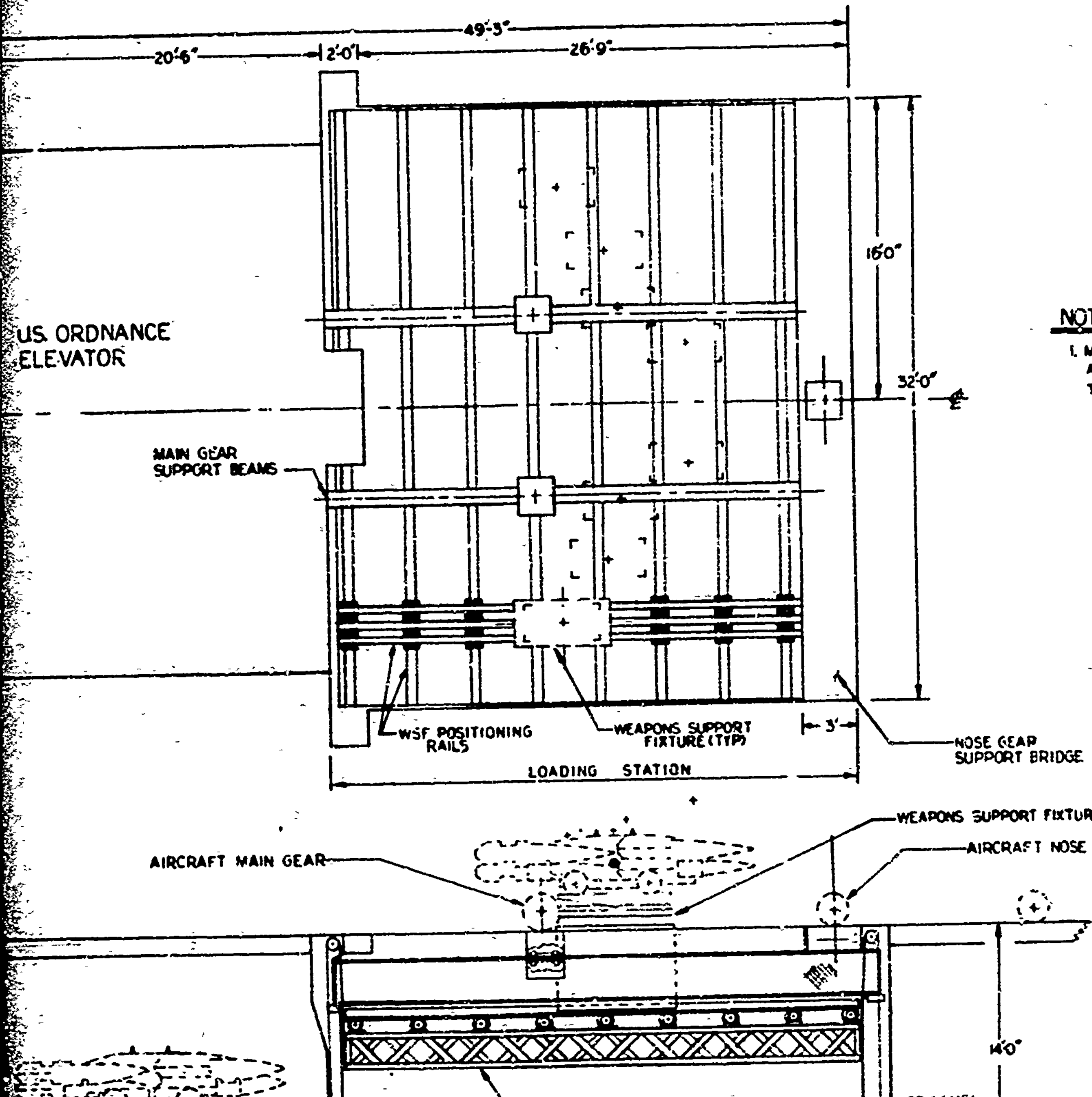


FIGURE 3, UNIT LOAD REARMING STATION BASIC CONCEPT



NOTES

1. MAIN GEAR SUPPORT BEAMS AND SKIDS ARE SHOWN FOR THE A-7 AIRCRAFT

FIGURE 3, UNIT LOAD REARMING STATION BASIC CONCEPT

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B

weapons load is assembled on the upper stage elevator at the hangar deck level, raised to the 03 level and transferred to the rearming station elevator. Any delay in availability of either elevator causes a delay in the total rearming process.

The rearming station elevator is equipped with a criss-cross pattern of rails which support the weapons support fixtures and enable movement of the fixtures in the lateral and longitudinal directions. The three rails under each weapons support fixture are attached to the lateral-direction rails by slotted ball bushings. Also, the weapons support fixtures are attached to the longitudinal-direction rails by slotted ball bushings. To move the weapons support fixture laterally, the entire assembly, weapons support fixture plus the three longitudinal rails, moves laterally.

The basic concept requires a great deal less below deck space than either the baseline or automated concepts. The deck opening has been sized for two-pass loading and requires the same area as the baseline concept. Below deck, the basic concept requires approximately 1/4 of the volume required by the automated concept and about 1/3 the volume required by the baseline concept. However, the rearming time per aircraft for the basic concept will increase by a factor of 2 or more over the baseline concept.

2. Development of Subsystem Requirements

This section presents the requirements and major concepts for the rearming station subsystems. In most cases, the subsystem requirements and concepts generated will apply regardless of which rearming station concept it is used with.

a. Flight Deck Opening Requirements

From an analysis of the weapon station envelopes for the A-4, A-6, A-7 and F-4, it was determined that the elevator opening required for loading these aircraft is approximately 38-1/2 feet long by 32 feet wide. The weapon station patterns were sketched and overlays were made to investigate the possibility of reducing the deck opening. From the analysis, it was determined that, with the exception of the F-4 aircraft, the aircraft weapon station patterns were fairly compact. Therefore, an alternate concept was generated in which the F-4 can be rearmed by performing the loading in two passes. During the first pass, the aircraft nose gear is located at the normal position for loading, and the forward weapon stations are loaded. The aircraft is then moved forward and the aft stations loaded.

For a two-pass loading technique, two factors determine the deck opening size. First, the station must be large enough to load the forward stations of the F-4 and all the stations of the A-4, A-6 and A-7. Second, the opening must be large enough to load the aft F-4 weapon stations.

Figure 4 describes the weapon station locations and nomenclature for the F-4 aircraft. In order to determine the size of the deck opening for two-pass loading, it is necessary to determine the greatest weapon overhang from the center of the hooks to the aft end of the weapon. For two-pass loading, the forward stations 2, 4, 6 and 8 will be loaded with the nose gear at the normal position on the nose gear bridge. The aircraft will then be moved forward until the aft stations 1, 3, 5, 7 and 9 can be loaded.

The largest weapons which can be carried on the F-4 are as follows:

Sta. 1 & 9:	3 MK-79/TER (95.5")
	6 MK-82/MER (96.0")
Sta. 3, 4, 6 & 7:	SPARROW only
Sta. 2 & 8:	2 MK-79/TER (95.5")
Sta. 5:	600 Gal. Fuel Tank (Approx. 142")
	MK-4 Gun Pod (98.4")
	6-MK-82 SNAKEYE/MER (96.0")

The dimensions given are measured from the center of the suspension lugs to the aft end of the weapon.

Of the other aircraft considered, the A-6 requires the largest deck opening. The A-6 is capable of carrying the MK-4 gun pod on the wing and centerline stations and the AERO 1D Fuel Tank on all stations. To load these stores will require the greatest

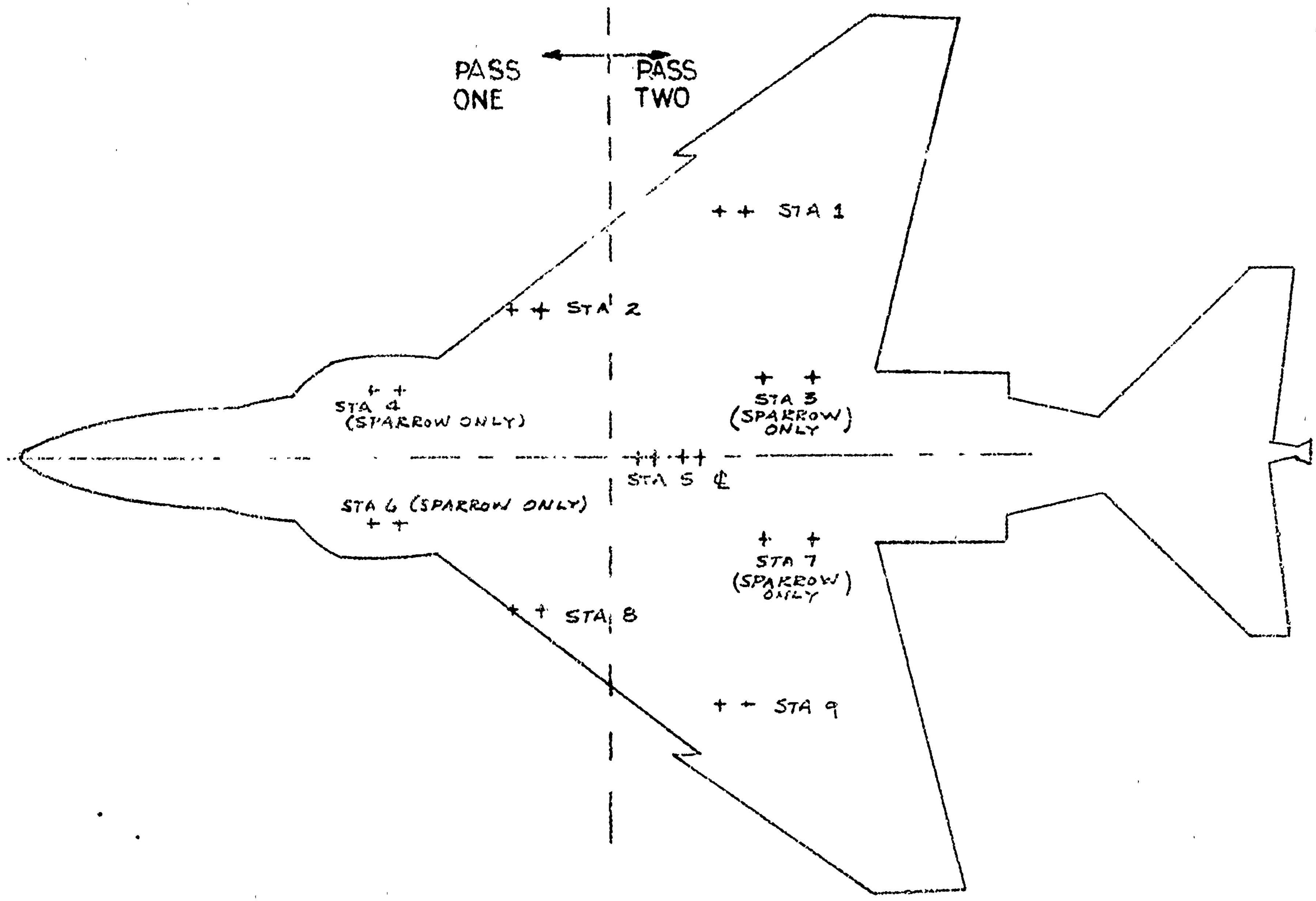


FIGURE 4, F-4 WEAPON STATIONS

lengthwise deck opening. Figure 5 and 6 show the envelopes required for loading the A-6 and F-4 with the two-pass technique. The A-6 requirement results in a deck opening length of 28'-9" and the F-4 requires a 25'-6" length. The F-4 envelope was generated by determining the longest weapon capable of being carried on stations 2 and 8, and then moving the nose gear forward until both fore and aft clearances were obtained for the longest weapon. The governing case for the first-pass F-4 loading was a MK-79/TER on stations 2 & 8, and for the second pass, a 600-gallon fuel tank on the centerline station. The 600-gallon fuel tank is approximately 260" long with an overhang of 142" aft of the center of the suspension hooks. This store establishes both the fore and aft clearance requirements for the second pass.

The deck opening for the A-6 was established from the clearances required to load an AERO ID Fuel Tank on all weapon stations.

The deck opening could be further reduced in size by using the following procedure for rearming:

- Place the weapons on the weapon support fixtures and perform alignment
- Move the loaded weapons support fixtures until all weapons will clear the deck opening

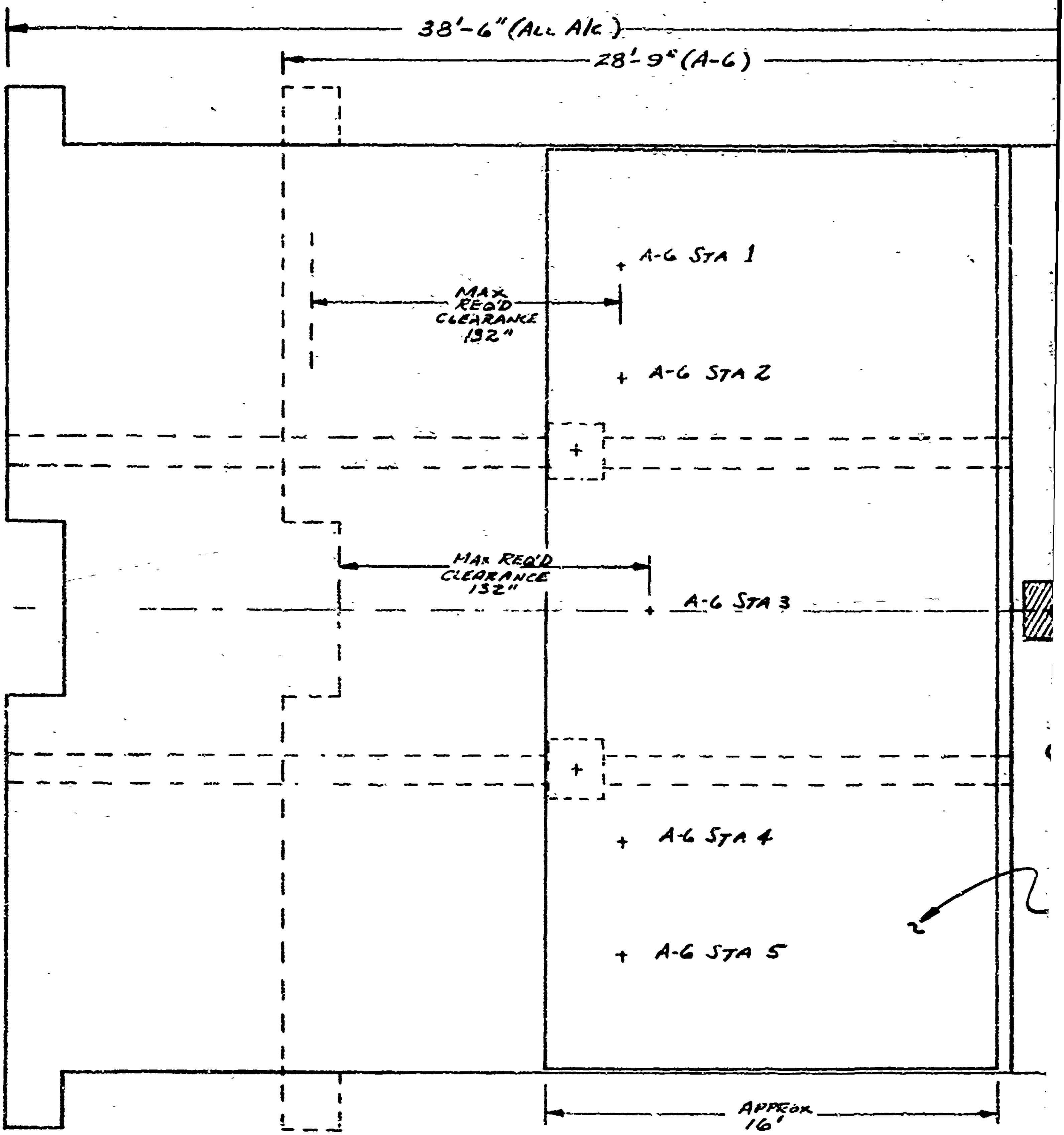
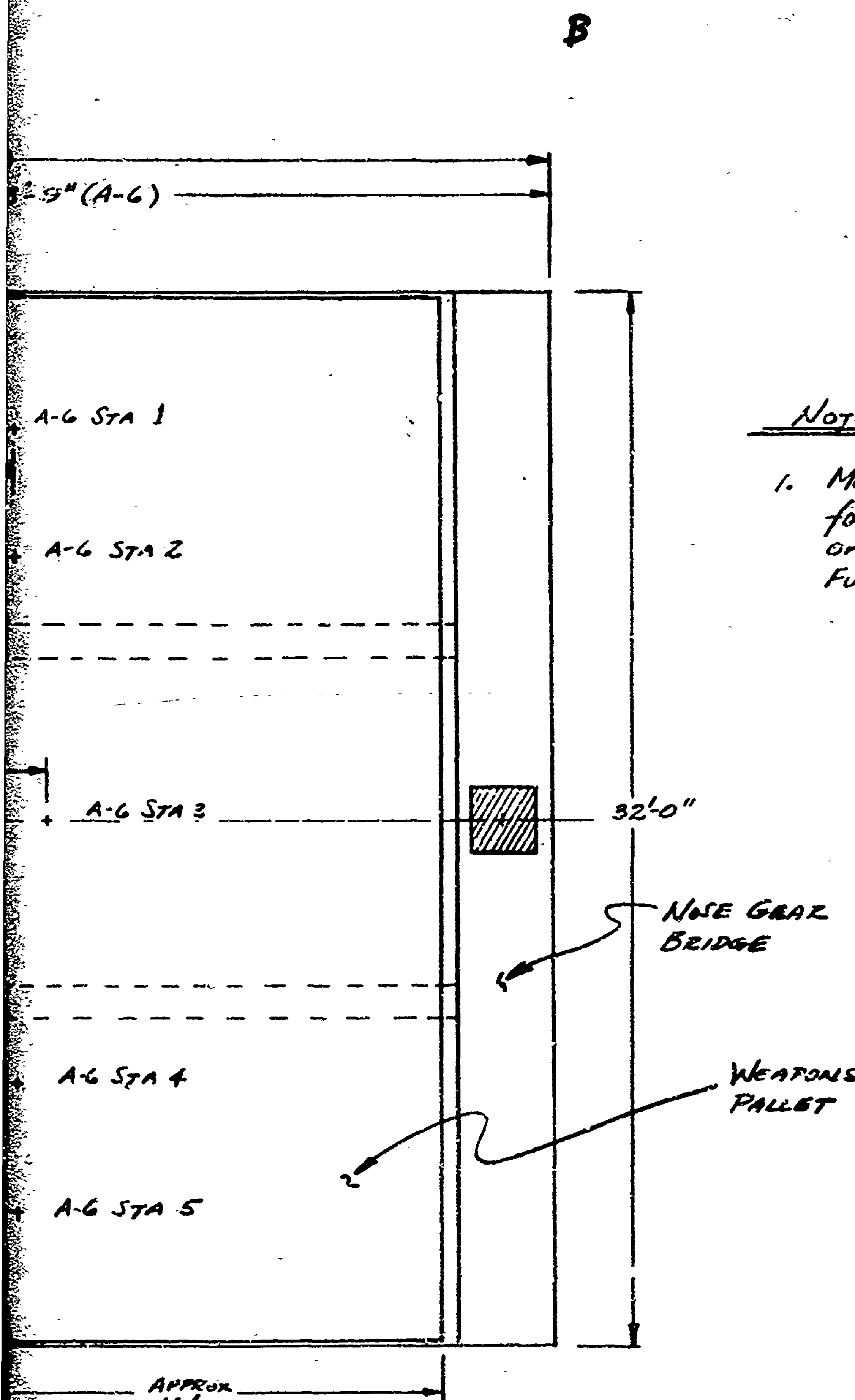


FIGURE 5, REARMING STATION DECK OPENING (A-6 REQ'T)



Notes

1. Maximum clearance for all stations based on loading an AERO ID FUEL TANK.

STATION DECK OPENING
(A-6 REQ'T)

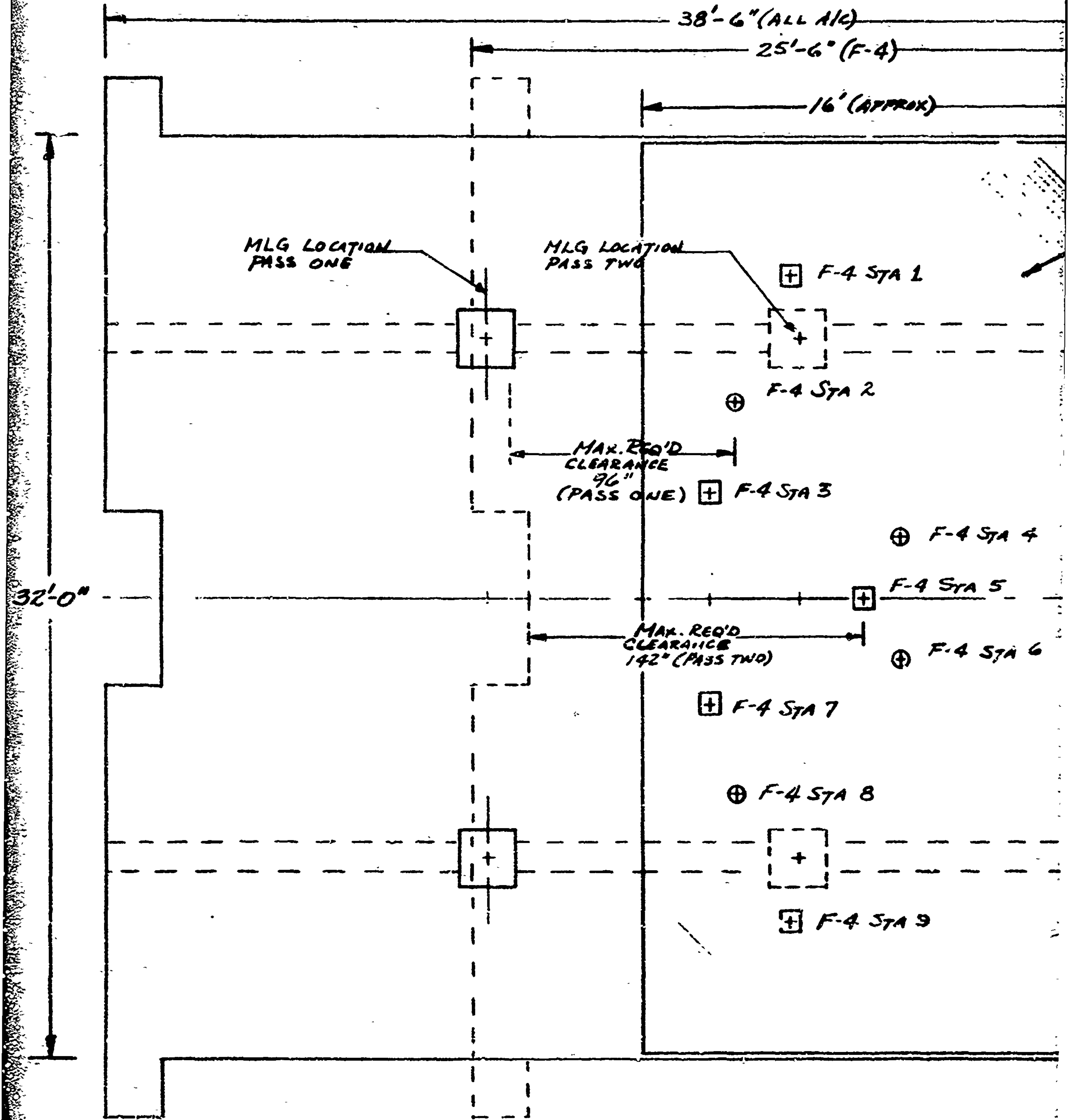
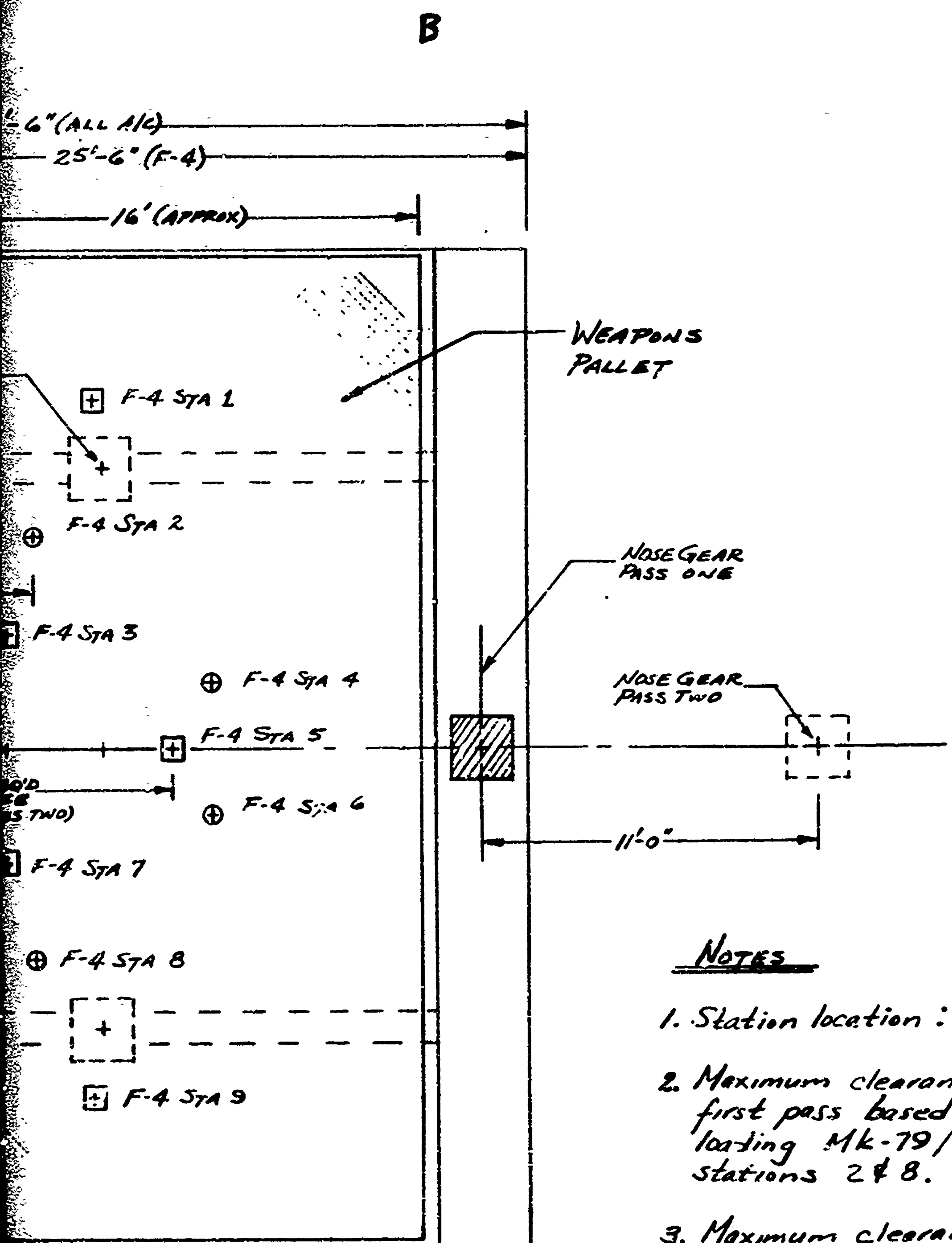


FIGURE 6, REARMING STATION DECK ...
(F-4 REQ'T)



NOTES

1. Station location : ⊕ First pass, ⊞ Second pass
2. Maximum clearance for first pass based on loading Mk-79/TER on stations 2 & 8.
3. Maximum clearance for second pass based on loading a 600-gal Fuel Tank on Station 5.

...ARMING STATION DECK OPENING
(F-4 REQ'T)

- After the elevator is raised to the flight deck and the weapons have cleared the deck opening, position the weapons support fixtures for loading.

Using this procedure, the deck opening would have to be sized for the maximum length weapon, which in this case is the 600-gallon fuel tank. The deck opening for the F-4 second pass loading has been sized for the 600-gallon fuel tank, thus a deck opening of 25'-6" x 32' could be acquired by using this procedure. However, the impact on loading time for additional handling and moving of the weapons support fixtures would negate the small savings gained in deck space. For the baseline rearming station, it is recommended that a two-pass station 28'-9" in length and 32' wide, be used.

b. Weapons Pallet Requirements and Concepts

(1) General

The weapons pallet is a platform used to support and orient the weapon support fixtures on the rearming station elevator. The basic function of the pallet is to accurately locate the weapons on the elevator to achieve proper alignment for mating weapons, lugs and aircraft hooks during unit loading, and to conserve time.

The weapons pallet can be visualized as analogous to an ammunition clip used in automatic rifles. The weapons are arranged on the pallet, the pallet is moved onto the elevator,

the elevator is raised and the weapons latched to the aircraft, much the same as the individual rounds are loaded into a clip and the clip inserted into an automatic rifle.

Two basic approaches have been investigated for the weapons pallet. The first concept investigated consists of a "universal" pallet, that is, one which will accommodate all carrier-based aircraft considered in this study and all conventional weapons carried by these aircraft. In this concept, the pallet is a platform equipped with rail systems for positioning the weapon support fixtures for the specific aircraft to be loaded. The weapon support fixtures are used for all aircraft and the pallet is configured for a particular aircraft prior to loading by positioning the fixtures to correspond to the aircraft EBR pattern. After the support fixtures are positioned, the weapons are adjusted for proper vertical, longitudinal, lateral and angular alignment.

With this concept, only one pallet is required per loading station, although two would be desirable from the standpoint of time savings. If two pallets were provided for each loading station, the positioning and alignment of one pallet could be accomplished concurrently with the loading of the aircraft using a second pallet, thus reducing dead time during the operation.

The second concept consists of a weapons pallet custom designed for each aircraft type to be loaded. For this concept, the pallet is equipped with support pads and support fixtures mounted on the pallet at the proper longitudinal and transverse locations to match the pylon locations of the specific aircraft to be loaded. The height of the support pads are pre-determined to enable loading each aircraft station with a minimum vertical travel. The minor adjustments are provided for in the support fixtures, which are permanently attached to the support pads. A minimum of one pallet for each aircraft type will be required with this concept, although two would be desirable to conserve time. The size of the pallet for each aircraft would vary since the weapon station patterns are different for each aircraft. With the exception of the F-4 aircraft, a pallet approximately 16 x 28 feet could be used to load all aircraft considered. The F-4 will require a pallet approximately 28 x 28 feet.

Either concept is capable of handling weapon skids pre-loaded with MER, TER or single weapons. As can be seen from figures 7 and 8, the A-4, A-6 and A-7 aircraft stations have a fairly compact pattern, but the F-4 station pattern requires approximately twice the area as the other aircraft.

The weapons pallet area requirements were determined by preparing layouts of each aircraft weapon station pattern on

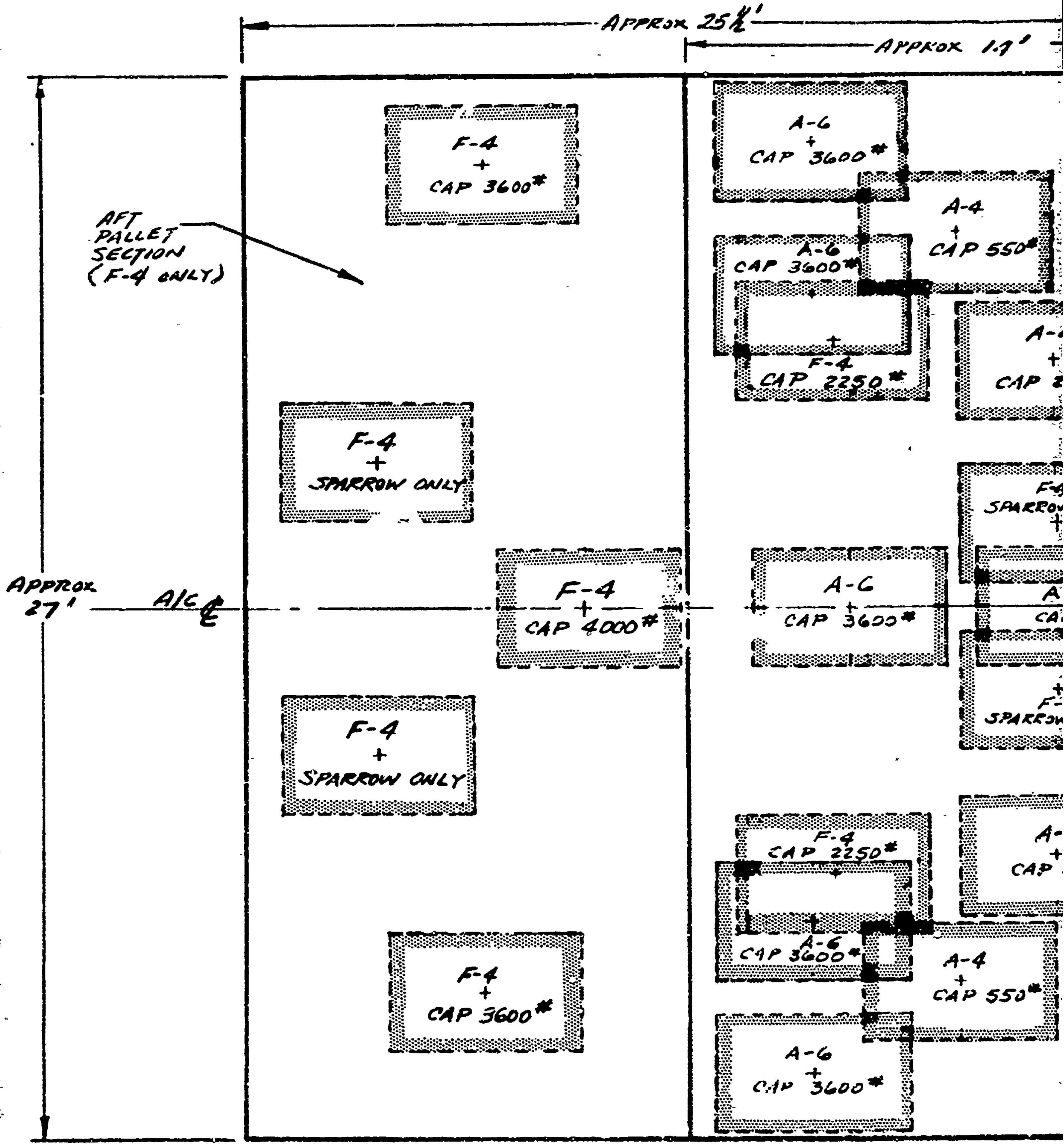
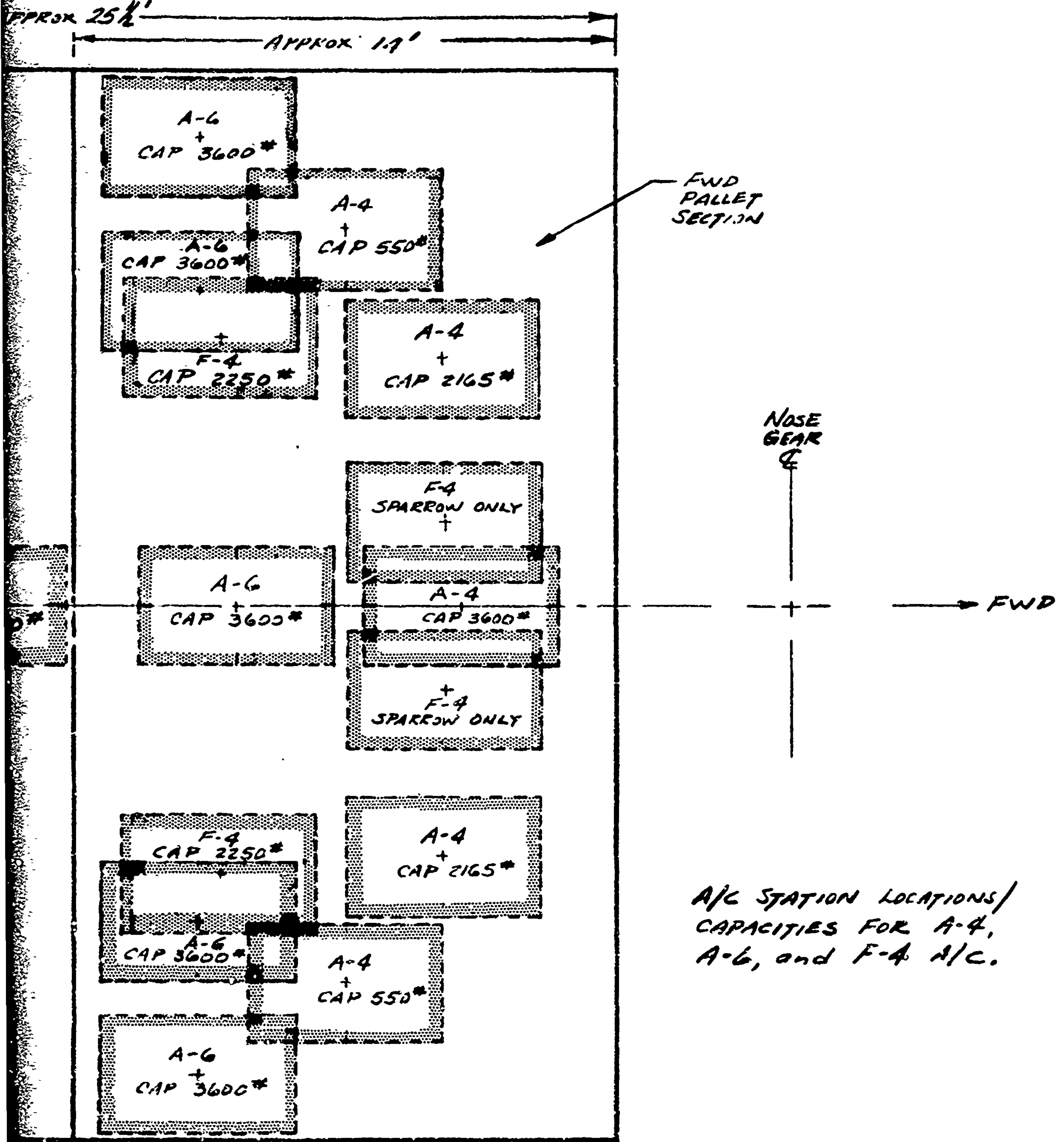


FIGURE 7, WEAPONS PALLET FOR

B



7. WEAPONS PALLET FOR A-4, A-6 & F-4 A/C

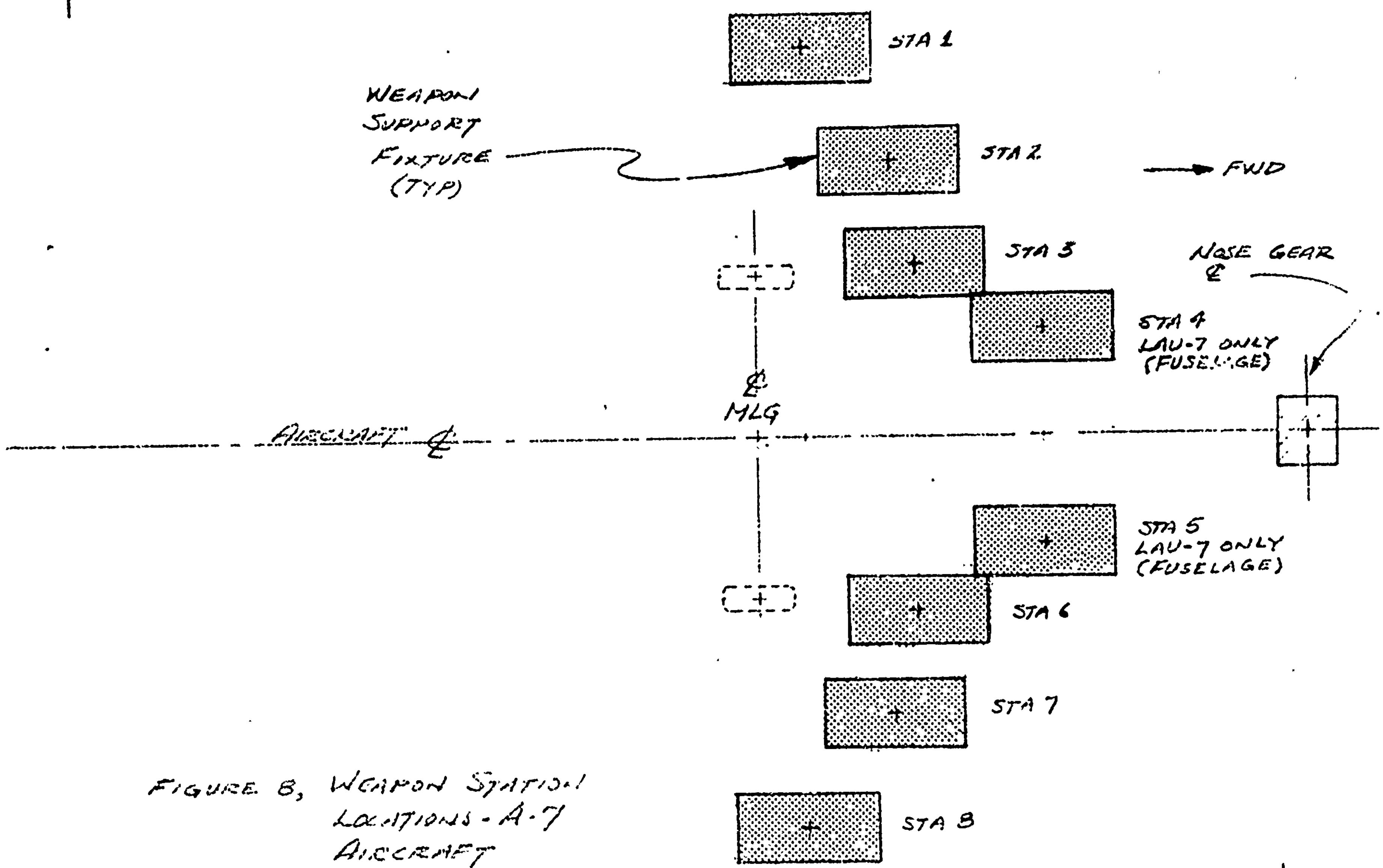


FIGURE 8, WEAPON STATION LOCATIONS - A-7 AIRCRAFT

transparencies and overlaying these to establish the configuration for a universal pallet for all aircraft. Figure 7 illustrates the resulting pallet dimensions and weapon station patterns for the A-4, A-6 and F-4 aircraft, and figure 8 depicts the A-7 weapon station pattern. The A-7 aircraft presents special pallet requirements due to the interference between the inboard wing stations and the main landing gear wheel.

(2) Pallet Concepts for A-4, A-6 and F-4 Aircraft

In developing concepts for the weapons pallet, two approaches were taken. First, to develop a universal pallet configuration which would accommodate all aircraft, and, second, to develop a specialized pallet for each aircraft type. Since the A-7 presented the most problems in the pallet design (caused by interference between the main landing gear and the inboard wing station), it was decided to first develop the A-7 pallet and attempt to adapt this pallet to other aircraft. As it turned out, this was a wise choice, since it resulted in the development of a universal pallet system which is capable of loading all aircraft including the A-7, without resorting to specialized equipment.

The development of the A-7 pallet is discussed in a later section of this report. This section will discuss the pallet for the A-4, A-6, and F-4 aircraft.

In Figure 7, the aircraft weapon station locations and capacities are shown superimposed on the weapons pallet. Each shaded rectangular block represents an initially sized 3' x 5' weapon support fixture, the center of which, corresponds to the center of the ejector bomb rack hooks. As can be seen, the weapons stations form a fairly compact pattern, except for the F-4 aircraft. If the weapons pallet is designed as two sections, one for loading the A-4, A-6 and forward F-4 stations, and the other for the remaining aft F-4 stations, the size of the pallet and elevator can be greatly reduced. This, however, results in two choic for loading the F-4. Either two elevators are provided (one for forward pallet section and one fo aft pallet section) to load the F-4, or one elevator is used to raise both pallet sections. For redundancy, it would be more advantageous to provide two elevators, one for each pallet section, so that a back-up system would be provided. For example, in the event of failure of the forward elevator, the A-4 and A-6 could still be loaded by positioning the nose gear bridge such that the aft pallet section could be used instead of the forward section and the F-4 could be loaded by making two passes. The two passes would consist of locating the nose gear bridge aft of the normal position so that the forward stations could be loaded with the aft pallet elevator, moving the aircraft forward to the normal nose gear position and loading the aft stations.

The weapons pallet will require a minimum of 5 movable platforms per section to enable loading of the A-4, A-6 and F-4. All pallet platforms must be capable of moving in a longitudinal and lateral direction, if a two-section pallet is used and if redundancy is desired.

The lateral and longitudinal positioning of the weapon/skid platforms is obtained by utilizing a system of low friction ball bushings and rails. The layout of the rails to provide the necessary adjustment of the platforms to load each aircraft and to move the weapons pallet on and off the elevator is shown in figure 9. The platform location for loading the A-6 aircraft is shown. To load any other aircraft, the platforms are moved longitudinally and laterally until they correspond to the aircraft station locations. Figure 10 is a view of Section A-A from figure 9 and illustrates the rail system which provides the adjustment capability.

The ball bushings and rails are items currently available on the market and have proven performance and reliability. The rail and ball bushings for the weapons pallet have been preliminarily sized based on a static analysis only (no shock loading) and weight estimates made in the appendix of this report. The use of air bearings and guide rails as an alternate for supporting and moving the weapons pallet is presented in Section V-B.2.b(4).

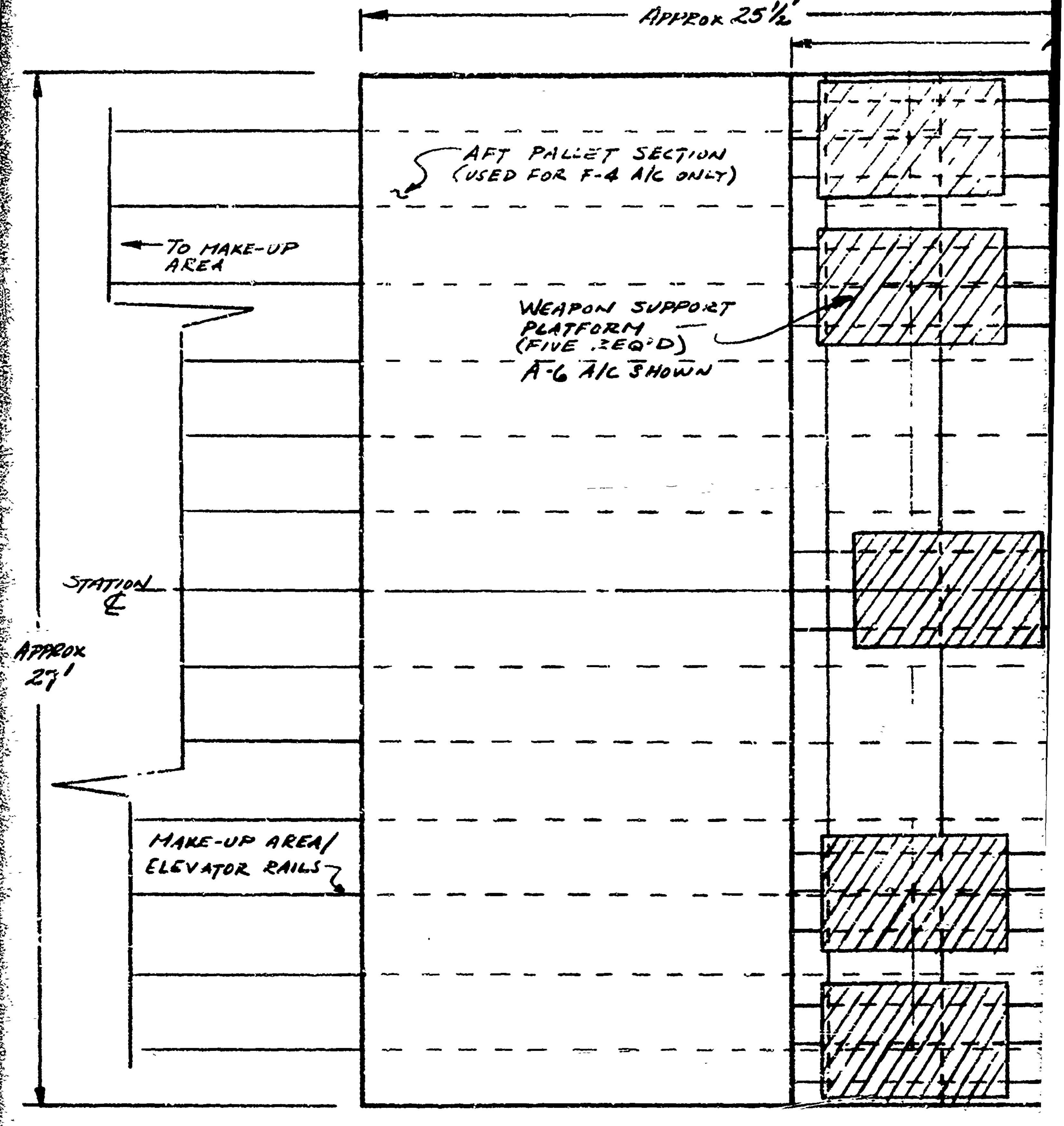
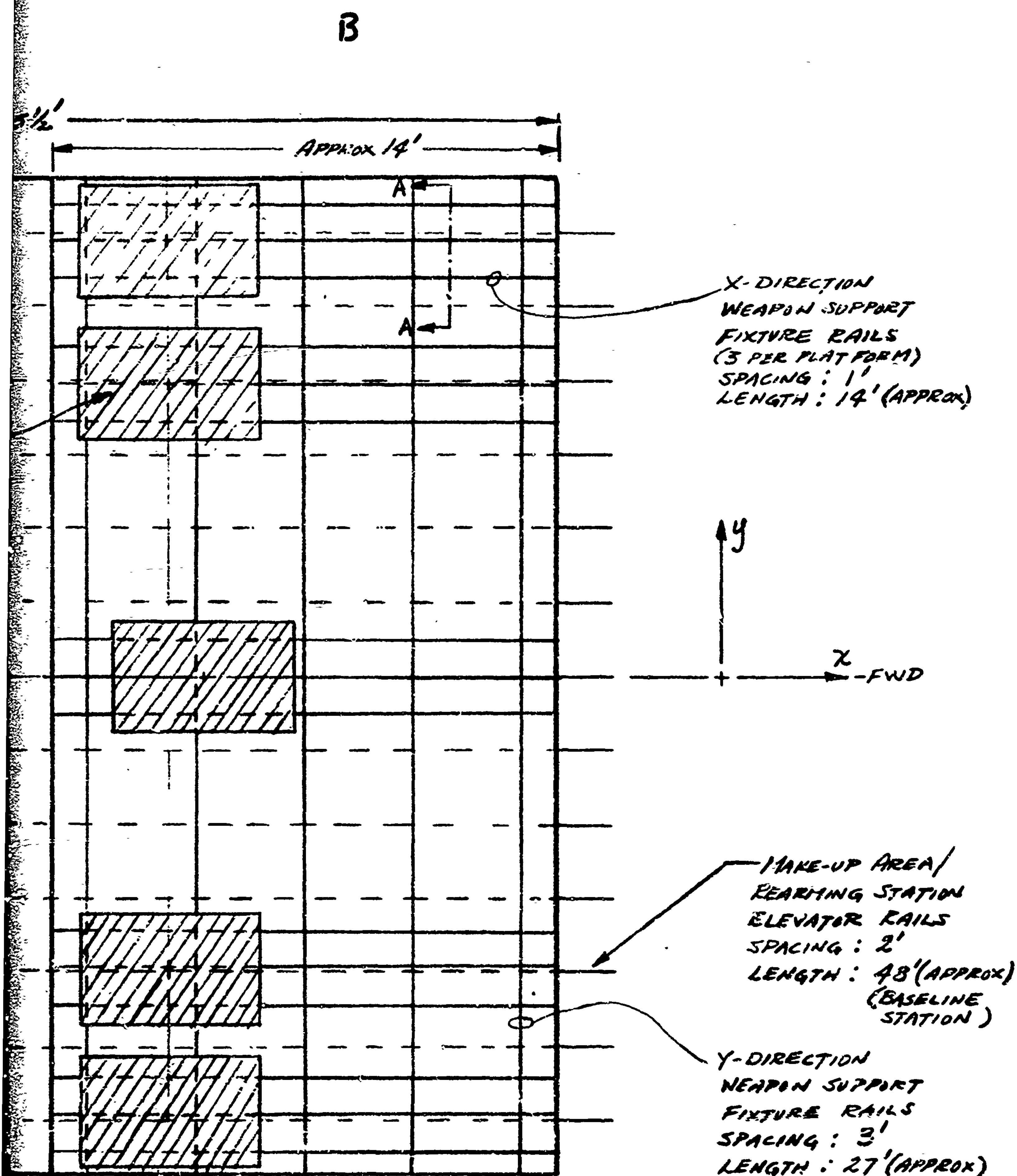
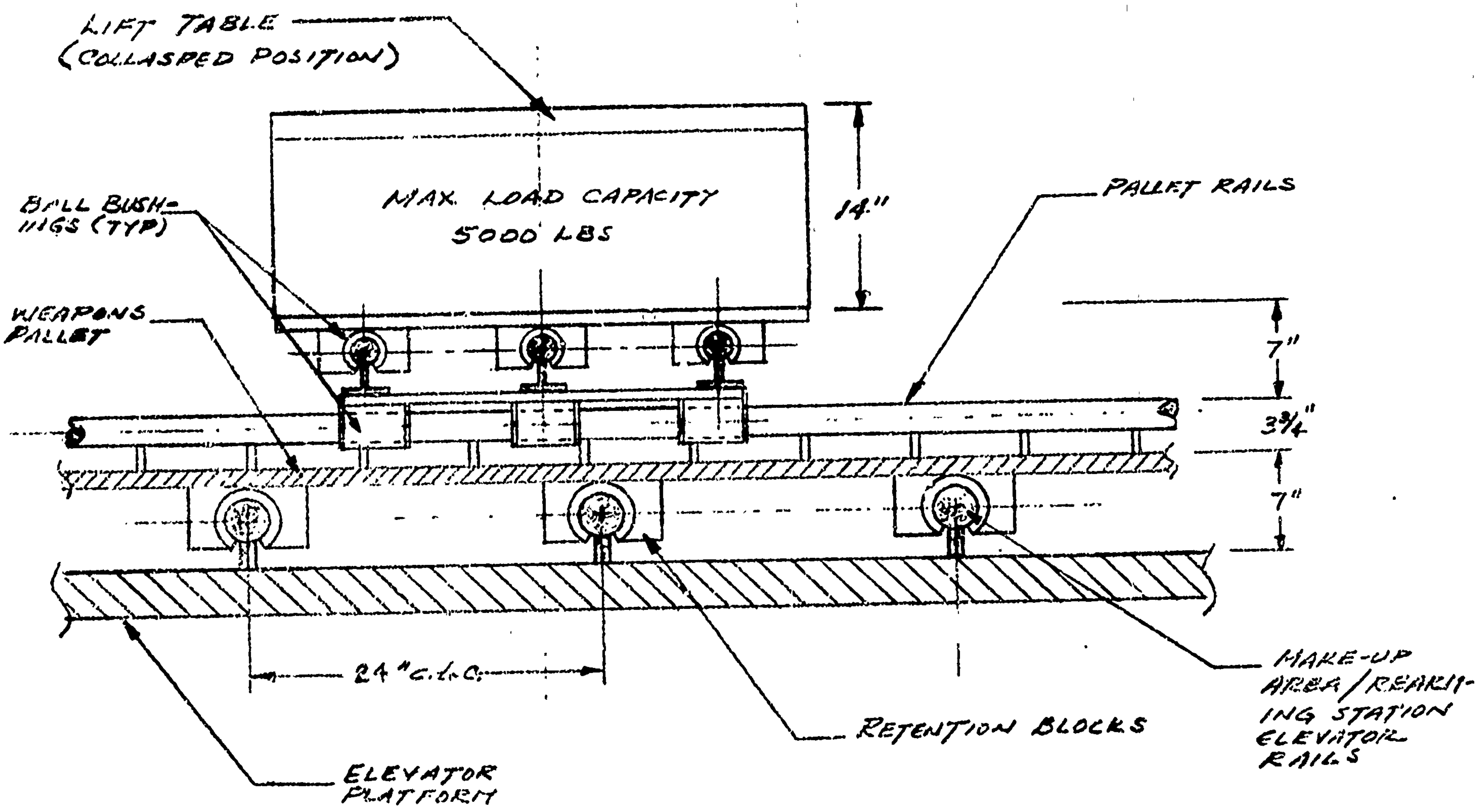


FIGURE 9, REARMING STATIO



9, REARMING STATION RAIL SYSTEM



SECTION A-A

FIGURE 10, WEAPONS PALLET & LIFT TABLE SUPPORT & MOVEMENT SYSTEM

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(3) Analysis of Specialized Ordnance Pallet for A-7 Aircraft

The results of an analysis to define a specialized ordnance pallet for the A-7 aircraft are presented in this section. The objectives of this task were to:

- Determine the best method for loading the A-7 inboard stations where the main landing gear interferes with weapons loading.
- Generate data for developing either a universal pallet configuration which would accommodate all aircraft, or a specialized pallet for each type aircraft.

Figure 11 is a sketch of the ordnance pallet which evolved from the analysis of an A-7 ordnance pallet. The upper left corner illustrates the technique used to avoid interference between the A-7 landing gear and the inboard station weapons. The two outboard sections of the pallet are mobile weapons platforms which move outward for raising to deck level and are moved inward when the weapon station elevator is in the full up position. Maximum lift for the weapons stations were based upon the highest and lowest skid/weapon combination for the A-7. The maximum lift requirement is approximately 3 feet.

The 31'-9" width required for the A-7 aircraft pallet is combined with the approximate 16' length required for the A-4,

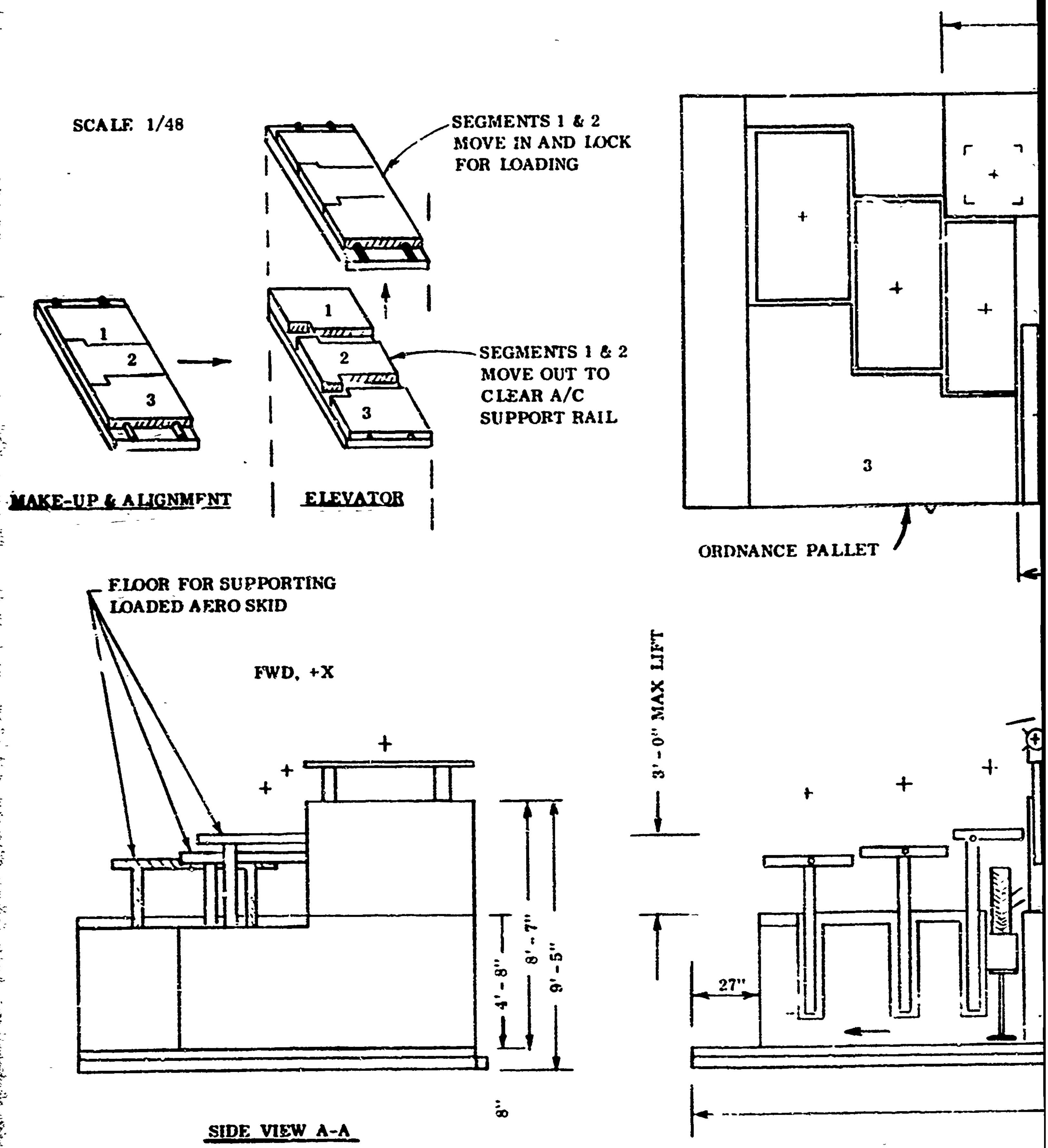

FIGURE 11. ORDNANCE PALLET FOR A-7 A/C ONLY

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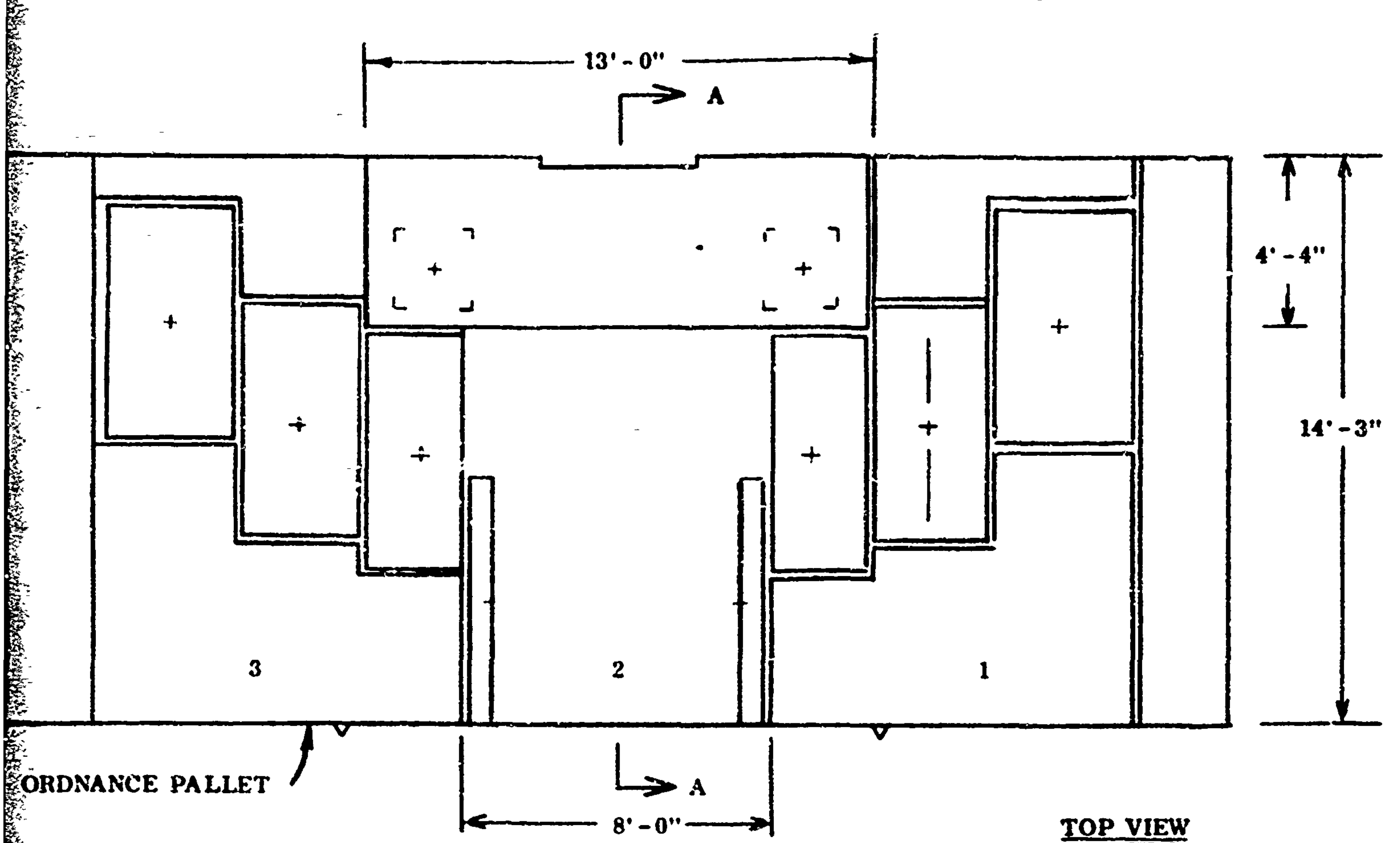
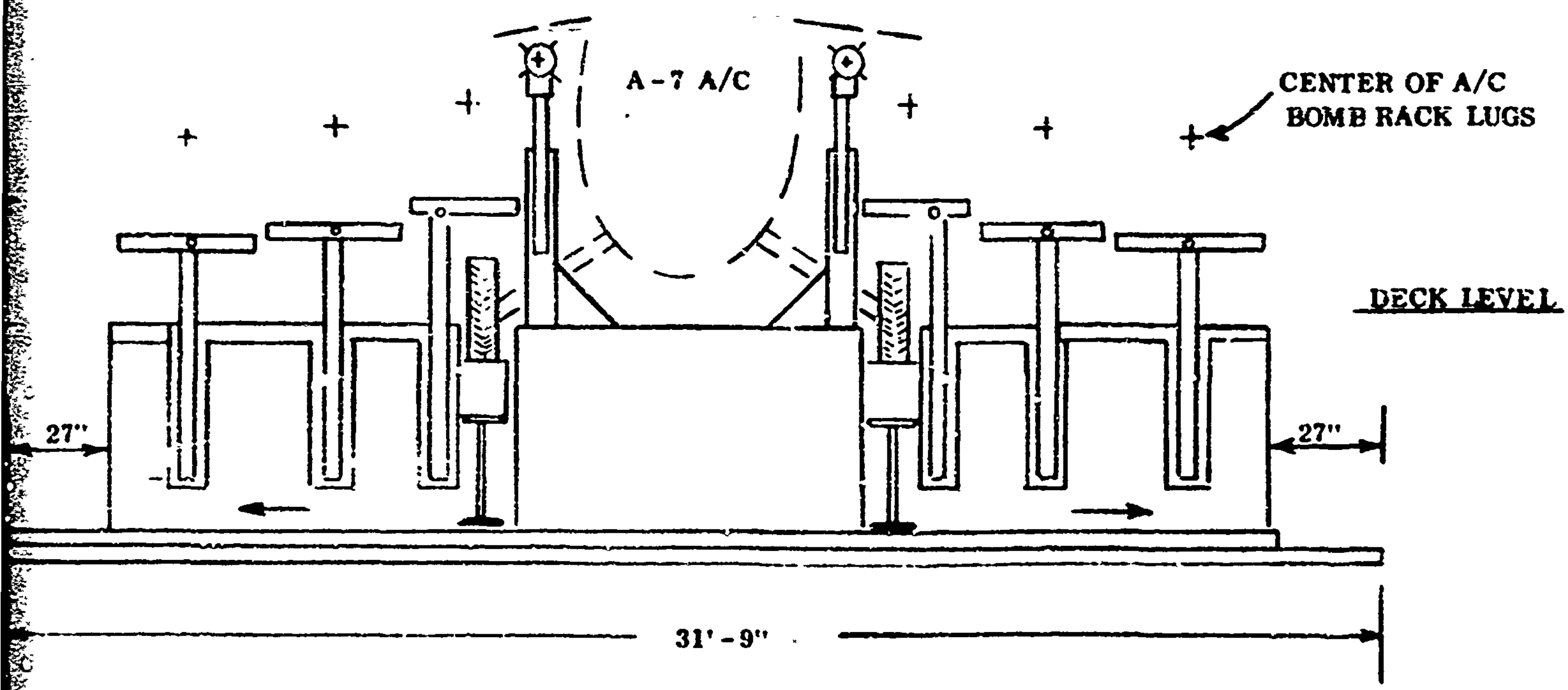

13' - 0"
A
4' - 4"
14' - 3"
3
2
1
A
ORDNANCE PALLET
8' - 0"

TOP VIEW


A - 7 A/C
CENTER OF A/C
BOMB RACK LUGS
DECK LEVEL
27"
27"
31' - 9"

A-6 and F-4 aircraft pallet to obtain the size of the baseline concept pallet (31 1/2' x 16 1/2').

From the analysis, it was determined that:

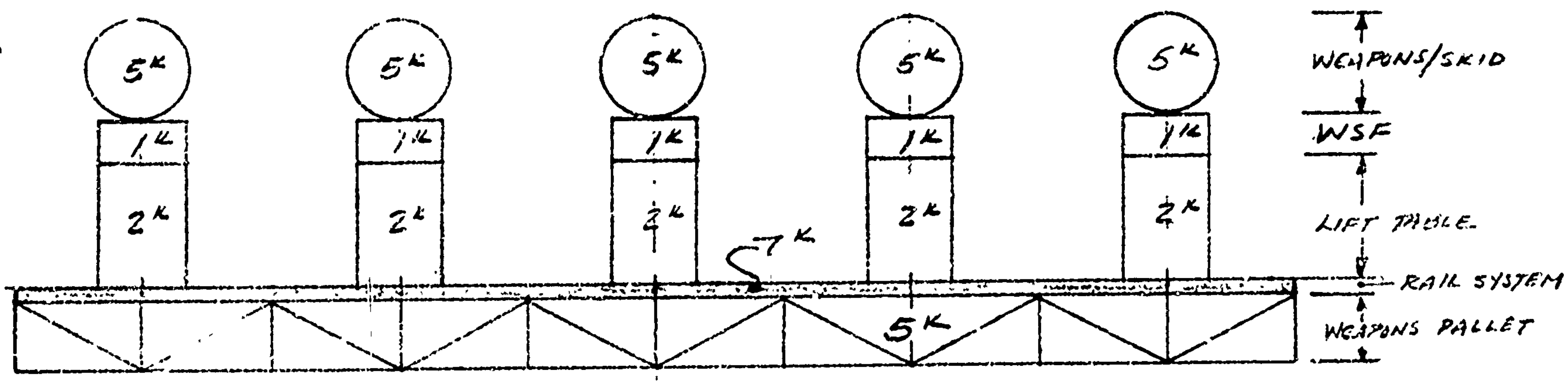
- Lateral movement of a cantilevered weapon as shown in Figure 11 is a good, straight forward technique for loading the A-7 inboard stations.
- The pallet make-up requirements strongly impact ordnance pallet design. For example, maximum weapon lift distance is increased because of the requirement for rolling the weapon skid onto the weapon support fixture at the loading ramp in the make-up area.
- The weapon support fixtures should have the capability of moving to the loading ramp for maximum flexibility.
- The specialized ordnance pallet will be almost as complex as the universal pallet. The specialized ordnance pallets would use critical storage space on the 03 level.
- A baseline concept, which will serve as a universal ordnance pallet, can be developed using the techniques for the specialized ordnance pallet.

(4) Alternate Concept for Weapons Pallet Support and Movement

The weapons pallet is supported and moved from the make-up area to the rearming elevator by means of low friction ball bushings and rails. The ball bushing-rail system offers a very low coefficient of friction (0.0011-0.0027) and restraint in six degrees of freedom; however, the system weight is significant. Since the bushing and rail weight is directly related to bushing life, the distance traversed from the make-up area to the rearming elevator (43 feet) places a serious requirement on the rail system. In order to reduce the system weight, an alternate concept will be investigated for supporting and moving the weapons pallet.

The baseline weapons pallet is approximately 16 feet x 32 feet in size and supports approximately 52,00[illegible] A breakdown of the loads supported by the pallet is shown in figure 12. The pallet must move from the make-up area to the rearming station elevator and back to the make-up area each time an aircraft is loaded (assuming one make-up area). The pallet must be under complete control at all times during this transit.

One method of moving and supporting the pallet is by air bearing platforms. The material handling industry uses air bearing platforms to enable one man to move loads of several



TOTAL WEIGHT : $5(8^K) = 40^K$

RAILS $= 7^K$

PALLET $= \underline{5}$

52^K

Figure [illegible]. WEAPONS PALLET LOADS BREAKDOWN

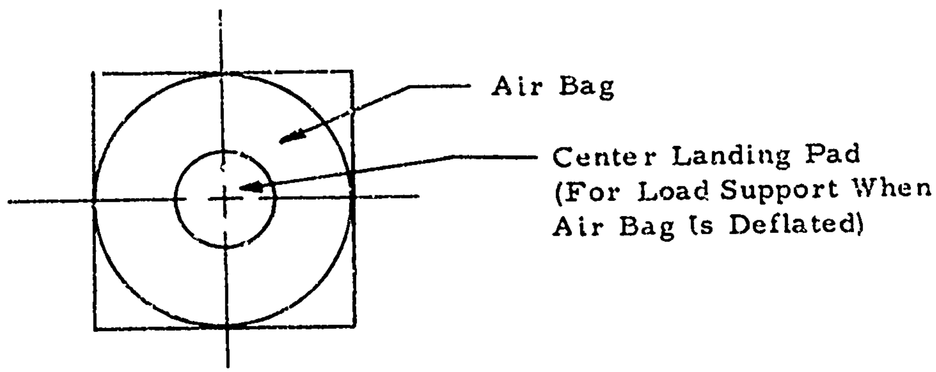
thousand pounds over relatively smooth and level surfaces. A typical coefficient of friction for smooth surfaces is 0.001 or less, which is comparable to the ball bushing-rail system. Air bearing platforms are made up of one or more modules to provide a wide range of load capacities and air pressure and flow requirements. Modules are available in standard sizes from 12" to 48" in diameter and load capacities from 2000-40,000 lbs.

For the weapons pallet movement, a concept such as shown in figure 13 is envisioned. The pallet platform is supported by 8 modules, each capable of up to 40,000 lbs. For moving the total weight of 52,000-lbs, eight modules (standard hardware item, commercially available) of 7000-lbs capacity would suffice. A 7000-lb capacity module requires an air flow of 5-30 CFM at a 25 psig pressure, weighs 18 lbs and is 21" in diameter. To provide for growth or to allow for overload factors, the modules may be uprated by using the next larger commercially available module size as shown in table 2 below.

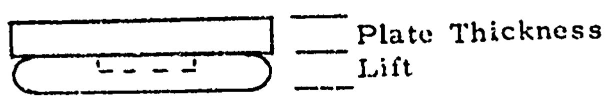
Figure 13 illustrates a pallet supported by a 8-48" diameter modules. This provides a great amount of growth and safety factor and the modules can be operated at lower pressures to accommodate lower load. Figure 14 is a graph of air bearing pressure vs. load capacity for a 48" diameter bearing. To support the 52,000 lbs pallet load would require an operating pressure of 3.5 psi in each of the 8 modules.

Table 2. Air Bearing Module Data

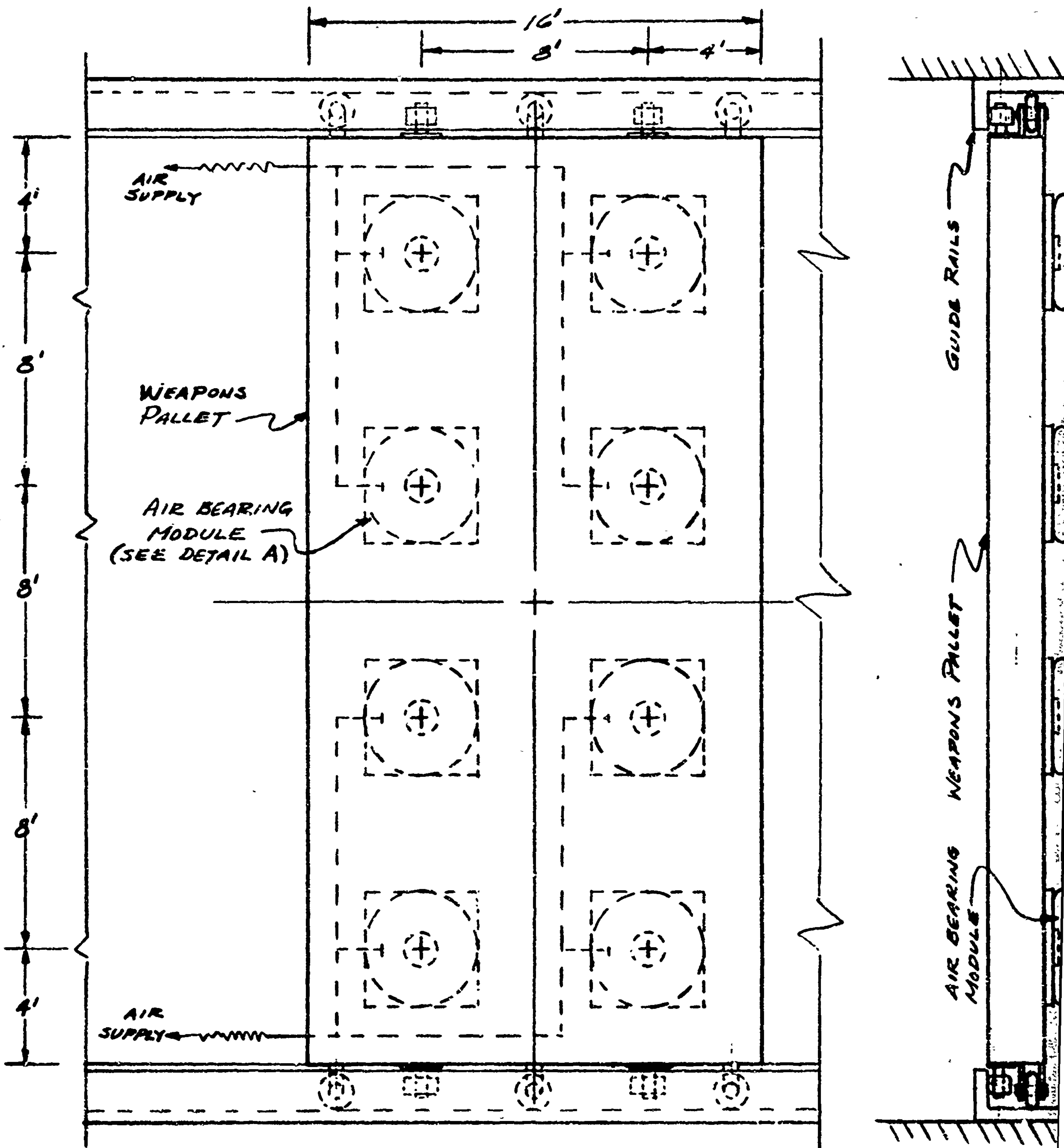
Model	Rated Loads, lbs.	Pressure, psig	Air Flow, CFM	WGT, lbs	Dia. in.	Thick in.	Lift in.
A	7,000	25	5-30	18	21	2	1
B	12,000		5-40	40	27	2	1 1/4
C	20,000		8-50	80	36	2 1/4	2
D	40,000		10-60	140	48	2 1/4	3



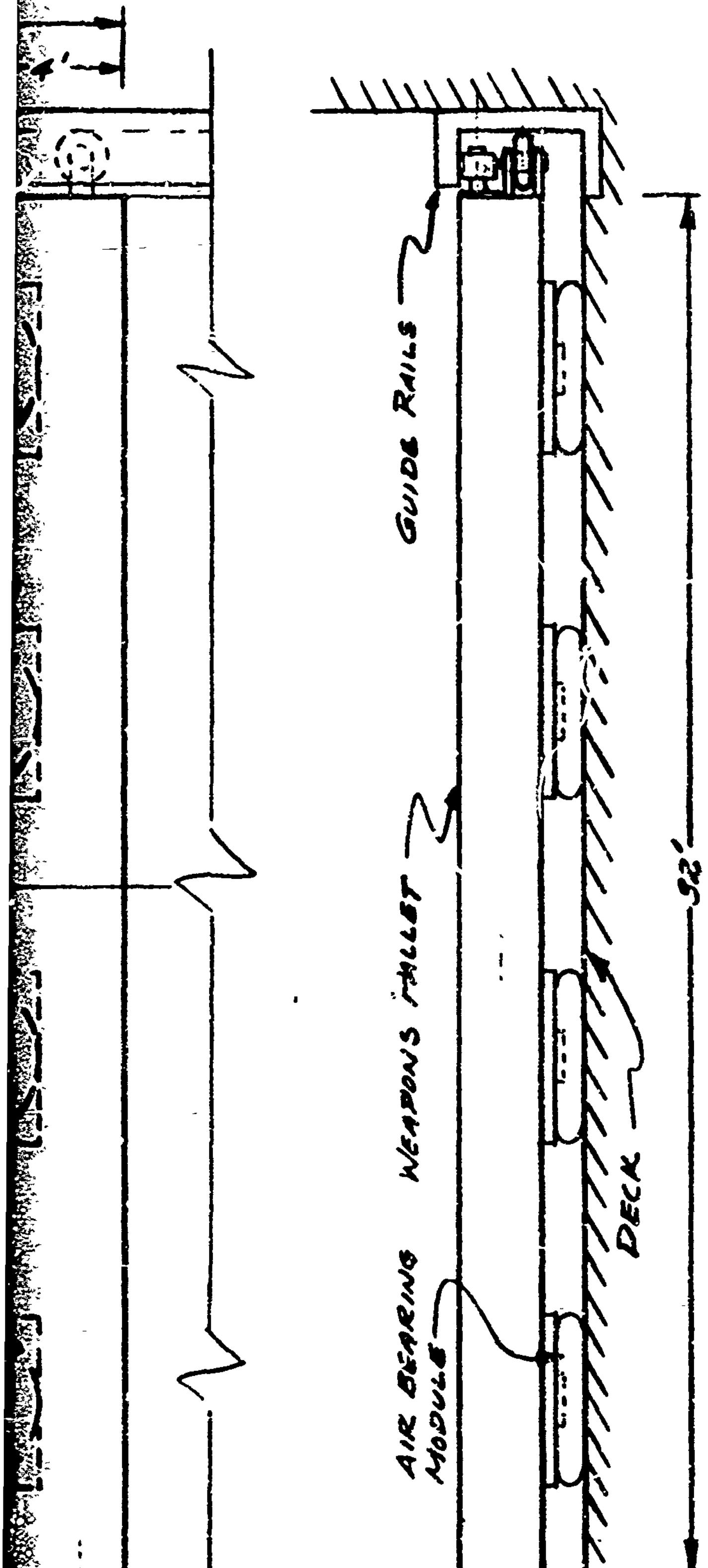
Bottom View

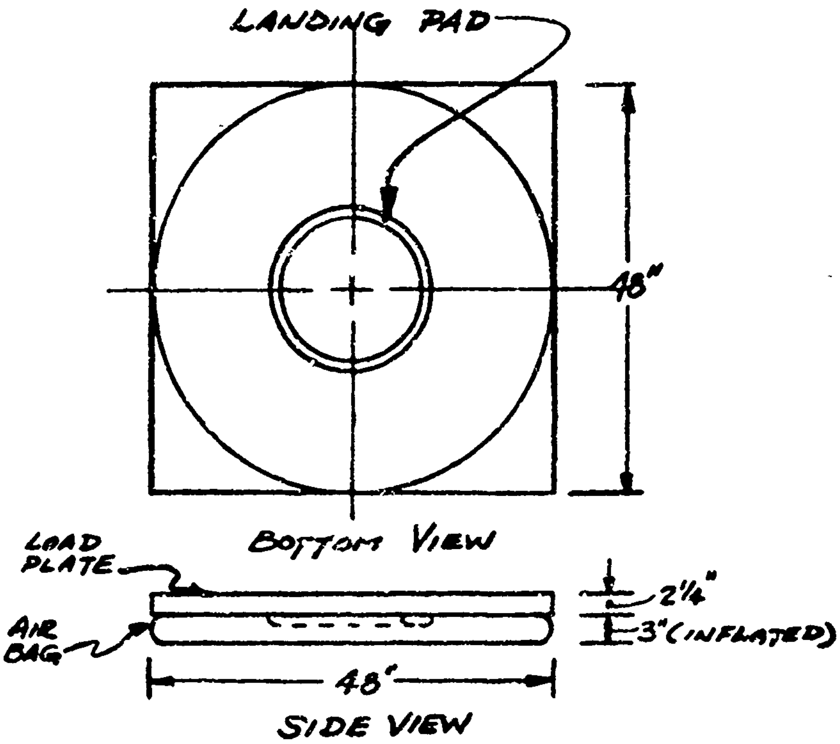


Side View


16'
8'
4'
AIR SUPPLY
4'
8'
8'
8'
4'
WEAPONS PALLET
AIR BEARING MODULE (SEE DETAIL A)
AIR SUPPLY
GUIDE RAILS
WEAPONS PALLET
AIR BEARING MODULE

B





DETAIL A

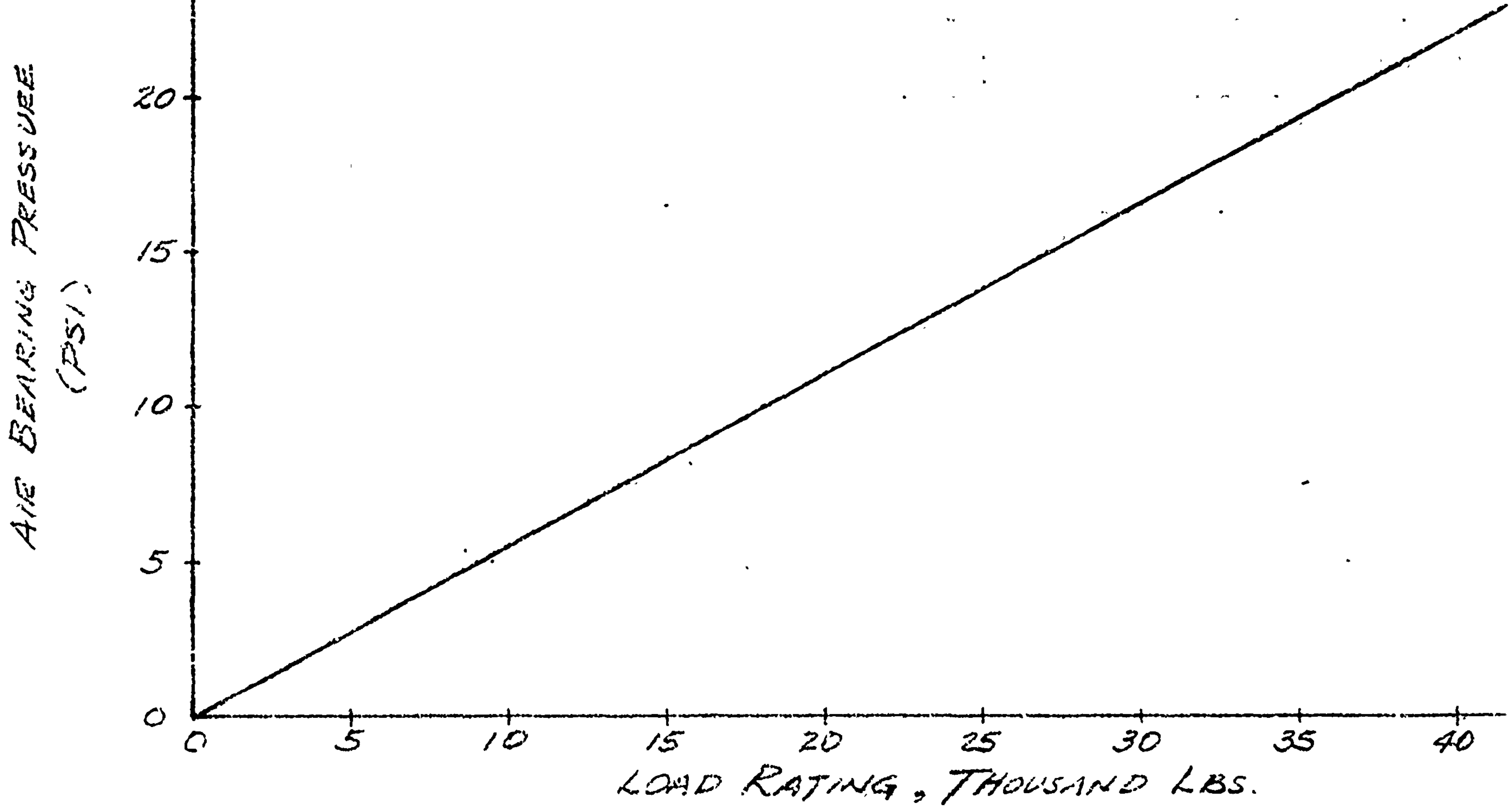
SCALE: 1" = 20"

FIG. 13, WEAPONS PALLET

AIR BEARING CONCEPT

SCALE: 1" = 4'

FIGURE 14, LOAD RATING VS BEARING PRESSURE
FOR
48" DIAMETER AIR BEARING
(AIR FLOW = 10-60 CFM)



The air bearing modules under the weapons pallet support the pallet so that it can be easily moved. Approximately 57 lbs. would be required to move the 52,000 lbs over a smooth and level surface. This value will increase for movement over rough surfaces, but one man should be able to provide the necessary motive force on level surfaces. On a pitching and rolling ship the required force will be much greater. Rough or dirty surfaces can be covered with plastic sheets to reduce the frictional resistance.

In figure 13, control of the pallet is maintained by the two guide rails extending the length of the make-up area and rearming elevator. The rails also provide a positioning index for the weapons pallet on the elevator. The air bearing modules are pressurized only during movement and positioning. When the pallet is stationary, the air flow is cut off, causing the pallet to rest on the module's center landing pads.

c. Weapon Support Fixture Requirements

The unit load rearming station must be capable of loading a wide range of weapons and aircraft. For this study, the A-4, A-6, A-7 and F-4 aircraft are considered since they are representative of the type carrier-based aircraft presently in the fleet. These aircraft represent various store heights and angles which the unit loader must be capable of providing. In table 3 below, the aircraft weapon station store heights and pitch angles are listed.

Table 3. Aircraft Weapon Station Data

Data Source	Aircraft	Weapons Stations	Height of Forward Hook above Static Groundline, inches	Pitch Angle Degrees
Ref 8	A-4	Centerline	49.1	5.0
		Wing - Sta. 75.0	49.7	6.0
		Wing - Sta. 113.7	50.0	6.0
Ref 8	A-6	Centerline		
		(w/rocket pak)	31.4	2.6
		(w/droppable store)	44.9	-1.3
		Wing - Sta. 141	71.5	4.6
		Wing - Sta. 95	72.4	4.6
Ref 8 & 9	A-7	Wing - Sta. 61.2	72.0	2.8
		Wing - Sta. 97.2	64.5	2.8
		Wing - Sta. 136.6	63.0	2.8
Ref 8	F-4	Centerline	51.0	-1.5
		Wing - Sta. 81.5	36.5	$-1 \pm 1/2$
		Wing - Sta. 132.5	45.5	-2.0

NOTE: Positive (+) Pitch Angle is Aircraft Nose Up;
Negative (-) Pitch Angle is Aircraft Nose Down.

In addition to the requirements generated for loading the lowest and highest aircraft station at the maximum and minimum store angles, it is also necessary to consider the lowest and highest ready service weapon/skid configuration. The maximum and minimum travel of the weapons support fixture must be such that the lowest ready service weapon/skid can be loaded on the highest aircraft station and the highest ready service weapon/skid can be loaded on the lowest aircraft station. The lug heights of various ready service weapons/skids have been tabulated in table 4, from reference 10. From the table, it is seen that the largest lug height occurs with an AERO 21A skid loaded with a TER and CBU-2A/A weapons and the lowest lug height is for a single MK 44 or 46 torpedo and an AERO 21A skid. These weapon configurations combined with the aircraft station heights determine the limits of travel required by the weapon support fixture. In figure 15, this data has been condensed and presented graphically. Notice that the governing weapon/skid height is not for the CBU 2A/A-TER but a LAU-3A/A-TER, since the F-4 cannot carry the CBU 2A/A-TER on the lowest station.

From figure 15, it is concluded that in order to load the highest and lowest aircraft stations (A-6 and F-4 respectively), a maximum vertical travel of 60.48" is required. Since the aircraft main landing gear support beams are estimated to be approximately 48" in depth, this dimension determines the location of the top of the

TABLE 4 WEAPONS IN READY SERVICE CONFIGURATION

WEAPON/SUSPENSION EQUIPMENT	HANDLING EQUIPMENT	SKID ADAPTERS	LUG HEIGHT INCHES	WEIGHT, POUNDS	C.G. LOCAT
MK-81, MER	AERO 21A	AERO 63A, 63A-1	36.31	2463.8	25.3
MK-81, MER		AERO 73A, 74A, 75A	45.47	3021.0	29.5
MK-81, TER		AERO 63A, 63A-1	36.50	1328.5	24.7
MK-81, TER		AERO 73A, 74A	44.0	1568.0	24.1
MK-82, MER		AERO 63A, 63A-1	38.0	4017.8	25.2
MK-82, MER		AERO 73A, 74A, 75A	47.38	4575.0	29.5
MK-82, TER		AERO 63A, 63A-1	39.00	2198.5	24.4
MK-82, TER		AERO 73A, 74A	46.31	2349.0	17.6
CBU-2A/A, TER		AERO 73A, 74A	51.64	3249.0	17.2
LAU-3A/A, TER		AERO 73A, 74A	50.48	1916.7	24.2
ROCKEYE II, MER		AERO 73A, 74A, 75A	50.06	4071.0	28.5
ROCKEYE II, TER		AERO 73A, 74A	48.96	2097.0	17.
WALLEYE		AERO 64 & LOWER 58A	30.75	1343.[illegible]	24.5
PHOENIX		AERO 89A & LOWER 58A	28.50	1315.0	24.9
MK 44 MODS 0 & 1		LOWER AERO 58A	25.92	681.0	19.4
MK 46 MOD 0 TORPEDO		LOWER AERO 58A	25.92	748.0	20.8
BULLPUP AGM-12C, 12C-2		LOWER AERO 58A	33.95	C - 1987.9 C-2 - 2001.0	18.2
LAU 69/A, TER		AERO 73A, 74A	51.52	2188.5	17.0
MK 4 MOD 0 GUN POD		AERO 58A LOWER	36.29	1638.0	15.
STANDARD ARM MOD 0		SPECIAL ADAPTER	32.70	1726.6	23.2
LAU-10A, TER	AERO 21A	AERO 73A, 74A	48.80	2268.0	24.3
MK 12 MOD 0 CHEM. TANK	AERO 12B/C	AERO 64B	27.00	-	14.7 (B 13.5 (CL
MK 12 MOD 0 CHEM. TANK	AERO 21A	AERO 58A LOWER	26.80	-	24.6 (B 24.8 (C
MK 77 MOD 4 FIRE BOMB	AERO 21A	AERO 58A LOWER & 64A	33.70	-	26.
MK 77 MOD 4 FIRE BOMB	AERO 12B/C	AERO 64B	31.30	-	14.
MK 83 LOW DRAG	AERO 21A	AERO 58A LOWER	26.81	1233.0	23.
CBU 2A/A	AERO 21A	AERO 58A LOWER	28.33	1108.0	-
LAU-69/A	AERO 12B	AERO 64B	29.25	718.5	-
MK 84 LOW DRAG	AERO 21A	AERO 58A LOWER	31.12	2218.0	
ROCKEYE II	AERO 21A	AERO 58A LOWER	26.00	724.0	
CBU-24B-29B	AERO 21A	AERO 58A LOWER	28.94	1078.0	

B

TABLE 4 WEAPONS IN READY SERVICE CONFIGURATION

SION	HANDLING EQUIPMENT	SKID ADAPTERS	LUG HEIGHT INCHES	WEIGHT, POUNDS	C.G. * LOCATION	NOTES
	AERO 21A	AERO 63A, 63A-1	36.31	2463.8	25.32	* C.G. LOCATED FROM ℄ OF FWD WHEEL OF SKID
		AERO 73A, 74A, 75A	45.47	3021.0	29.39	
		AERO 63A, 63A-1	36.50	1328.5	24.75	
		AERO 73A, 74A	44.0	1568.0	24.12	
		AERO 63A, 63A-1	38.0	4017.8	25.21	
		AERO 73A, 74A, 75A	47.38	4575.0	29.54	
		AERO 63A, 63A-1	39.00	2108.5	24.48	
		AERO 73A, 74A	46.31	2349.0	17.61	
		AERO 73A, 74A	51.64	3249.0	17.28	
		AERO 73A, 74A	50.48	1916.7	24.22	
		AERO 73A, 74A, 75A	50.06	4071.0	28.53	
		AERO 73A, 74A	48.96	2097.0	17.80	
		AERO 64 & LOWER 58A	30.75	1343.1	24.51	
		AERO 89A & LOWER 58A	28.50	1315.0	24.90	RAIL LAUNCHED
		LOWER AERO 58A	25.92	681.0	19.41	
PEDO		LOWER AERO 58A	25.92	748.0	20.81	
C,12C-2		LOWER AERO 58A	33.95	C - 1987.9 C-2 - 2001.0	18.22	RAIL LAUNCHED
		AERO 73A, 74A	51.52	2188.5	17.04	
POD		AERO 58A LOWER	36.29	1638.0	15.52	
OD 0		SPECIAL ADAPTER	32.70	1726.6	23.24	RAIL LAUNCHED
	AERO 21A	AERO 73A, 74A	48.80	[illegible]268.0	24.38	
.TANK	AERO 12B/C	AERO 64B	27.00	-	14.7 (BALLS) 13.5(CLUS.)	C.G. FROM FWD END OF SKID
.TANK	AERO 21A	AERO 58A LOWER	26.80	-	24.6 (BALLS) 24.8 (CLUS.)	
BOMB	AERO 21A	AERO 58A LOWER & 64A	33.70	-	26.90	
BOMB	AERO 12B/C	AERO 64B	31.30	-	14.3	C.G. FROM FWD END OF SKID
	AERO 21A	AERO 58A LOWER	26.81	1233.0	23.84	
	AERO 21A	AERO 58A LOWER	28.33	1108.0	-	
	AERO 12B	AERO 64B	29.25	718.5	-	
	AERO 21A	AERO 58A LOWER	3[illegible].12	2218.0		
	AERO 21A	AERO 58A LOWER	26.00	724.0		
	AERO 21A	AERO 58A LOWER	28.94	1078.0		

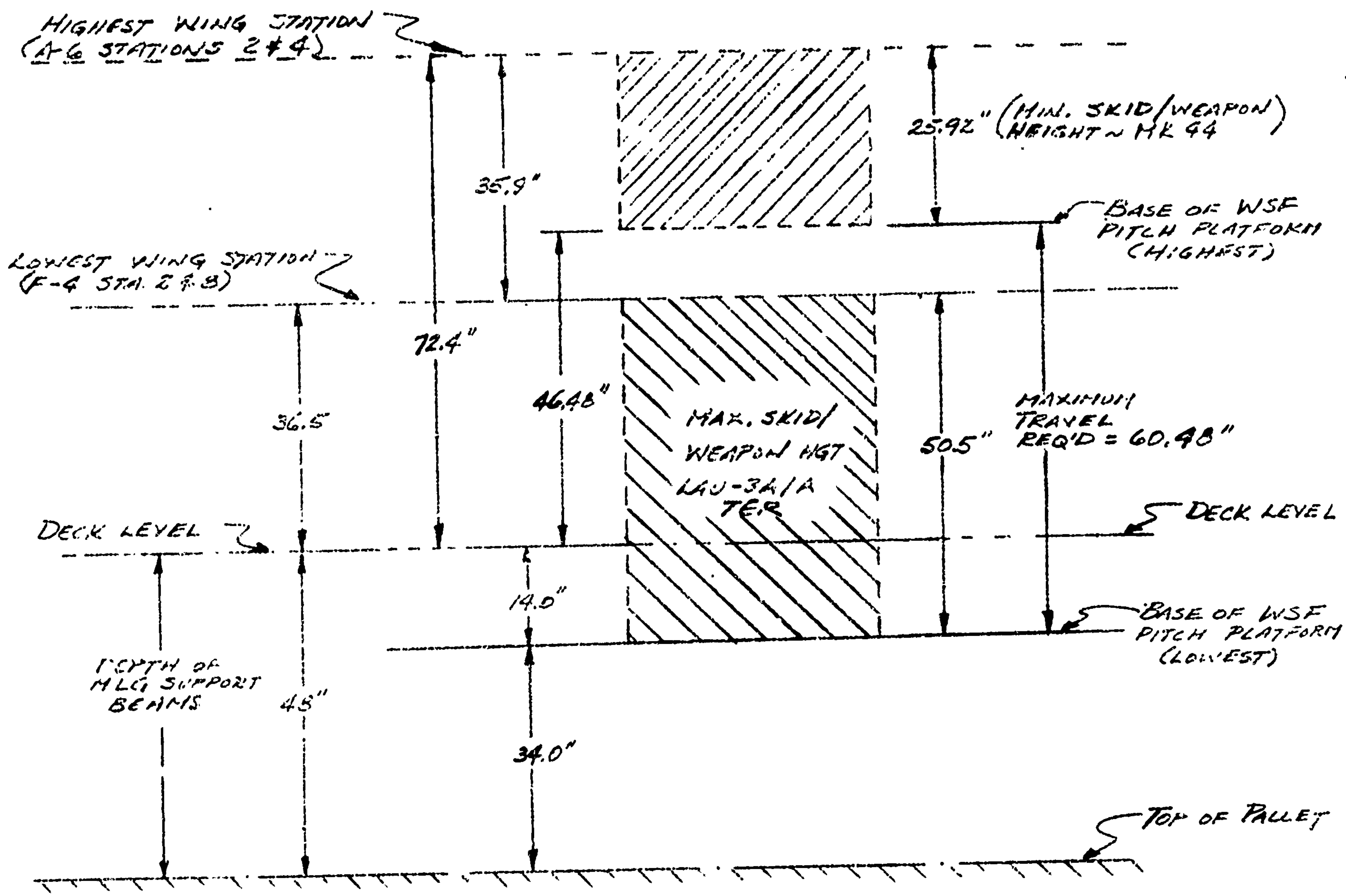


FIGURE 15, WEAPON SUPPORT FIXTURE –
MAXIMUM VERTICAL TRAVEL

9/27/71

weapons pallet. This allows 34" between the top of the lift table and the top of the weapons pallet available for the weapons support fixture.

The travel requirements for the weapons support fixture (WSF) will be as follows:

* Vertical------------+60.48"
o Longitudinal --------±4.0"
o Lateral ------------±2.0"
* Pitch --------------+10° (nose up)
  -7° (nose down)
o Yaw ---------------±2 1/2°
** Roll----------------±7°

DATA SOURCE

* Reference 8

o Engineering judgment based on available data

** Reference 11

The values for pitch, roll and yaw include an estimated allowance for such variables as tire pressure, fuel load, manufacturing tolerances, etc.

The weapons support fixture must have a capacity of at least 4575.0 lbs. to load the heaviest ready service configuration weapon/skid, which is 6-MK-82/MER on an AERO 21A skid.

C. ANALYSIS OF STRIKE-UP AND WEAPONS PALLET MAKE-UP CONCEPTS

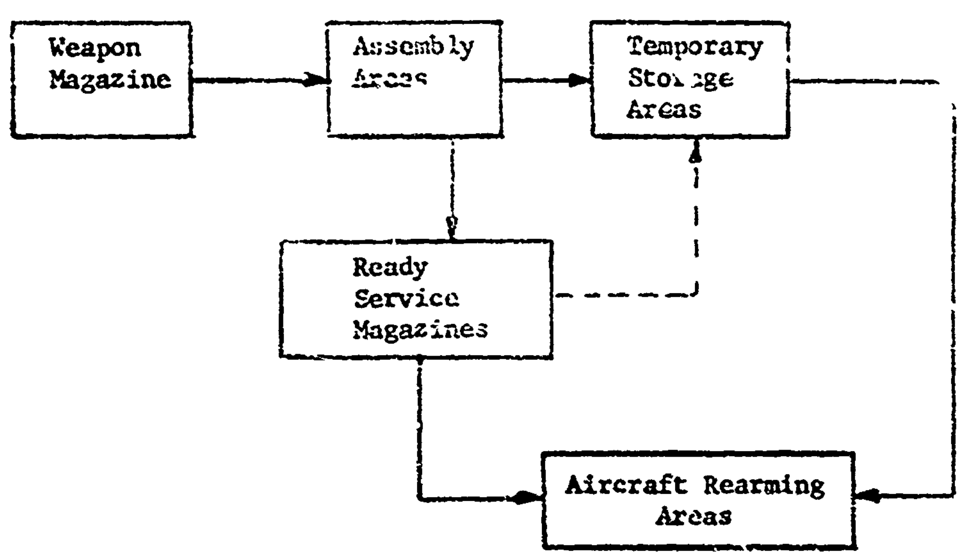
1. Introduction

The objective of this analysis is to investigate the:

- Requirements of ordnance strike-up from the magazine area to the pallet make-up area
- Requirements for weapons pallet make-up
- Most desirable configuration of the make-up area and best method of feeding the rearming station.

Conventional weapons flow from the weapons magazine to the aircraft rearming areas is discussed below for the existing "manual loading" operation. The impact of the rearming station on existing weapon flow processes are outlined in a following section.

2. Weapons Flow- Existing System



a. Weapon Magazine

The total weapons inventory is generally divided into at least two complexes, one forward and one aft, for duplicati n in event of damage or malfunction. This separation also provides multiple paths for loading weapons during strike-down and strike-up. Separate magazines are provided for different weapons types to assist in selecting weapons for different weapon mixes for different strike operations. Weapons of different levels of risk are stowed separately to hold down the risk level and the protective features required for the low risk weapons. Certain weapons require detection systems, high capacity blow-out ventilation, personnel showers, and special environmental condit ns. Certain pyrotechnics, which are difficult to extinguish once ignited, must be stowed in areas where minimum effect on vital ship areas will result from their inadvertent ignition.

The modular stowage system is used in carriers to facilitate interchangeability of weapons in the magazines. This system consists of a deck and overhead grid system and stanchions which can be arranged by ship's work force to accommodate a wide variety of weapons either bare or in pallets. The dunnage stowage system is an outgrowth of the modular system and consists of deck and overhead grids and stanchions for stowage of a wide variety of weapons in pallets, cradles and containers

b. Assembly Area

Bomb assembly is performed on an assembly-line type roller conveyor table. Bombs are lifted onto one end of the conveyor by a power operated hoist, and rolled past specialized operators who fit tails, fuzes, booster and arming mechanisms, using powered tools. Assembled bombs are lifted off the terminal end of the conveyor by a powered hoist and placed on a skid in an arrangement where they are prepositioned for installation on a multiple bomb rack.

Missiles are delivered to the carrier fully assembled in cradles. These cradles contain one or more missiles which has been completely checked and is ready for breakout and loading onto the aircraft.

c. Temporary Storage Areas

Prior to the first aircraft launch, the assembled bombs and missiles are moved to the hangar and flight decks and stowed in available areas in preparation for loading on the aircraft. Usually the area on the starboard side of the island is used to temporarily stow ready weapons on the flight deck for the first launches. The hangar deck is used to stow the remainder.

d. Ready Service Magazines

The ready service magazines are used to stow completely assembled and checked weapons. Also, preloaded multiple bomb

racks are stowed in this area. The ready service magazines will accommodate enough preassembled weapons for emergency measures and the magazine is then replenished during slack in operations. This area acts as a sort of reserve from which ready weapons may be drawn.

e. Aircraft Rearming Areas

The aircraft are loaded on the flight deck in areas designated as "safe for rearming." Weapons loading is performed, for the most part, manually.

3. Weapons Flow with Rearming Station

Weapons flow from the magazine areas to the main deck would not have to be changed in order to incorporate and utilize the baseline rearming system. Weapons could move from the lower decks of the ship by conventional methods and routes to the main deck level. From the main deck weapons on skids move along conventional routes until they are just below the weapons rearming station as illustrated in figure 16. From below the rearming station the weapons are shuttled to the weapons pallet make-up areas by high speed upper stage (U.S.) elevators.

The movement of bomb skids, weapons, bomb trucks, hoisting and handling equipment are eliminated on the flight deck with the unit load rearming station. Consequently, flight deck congestion and safety hazards are reduced.

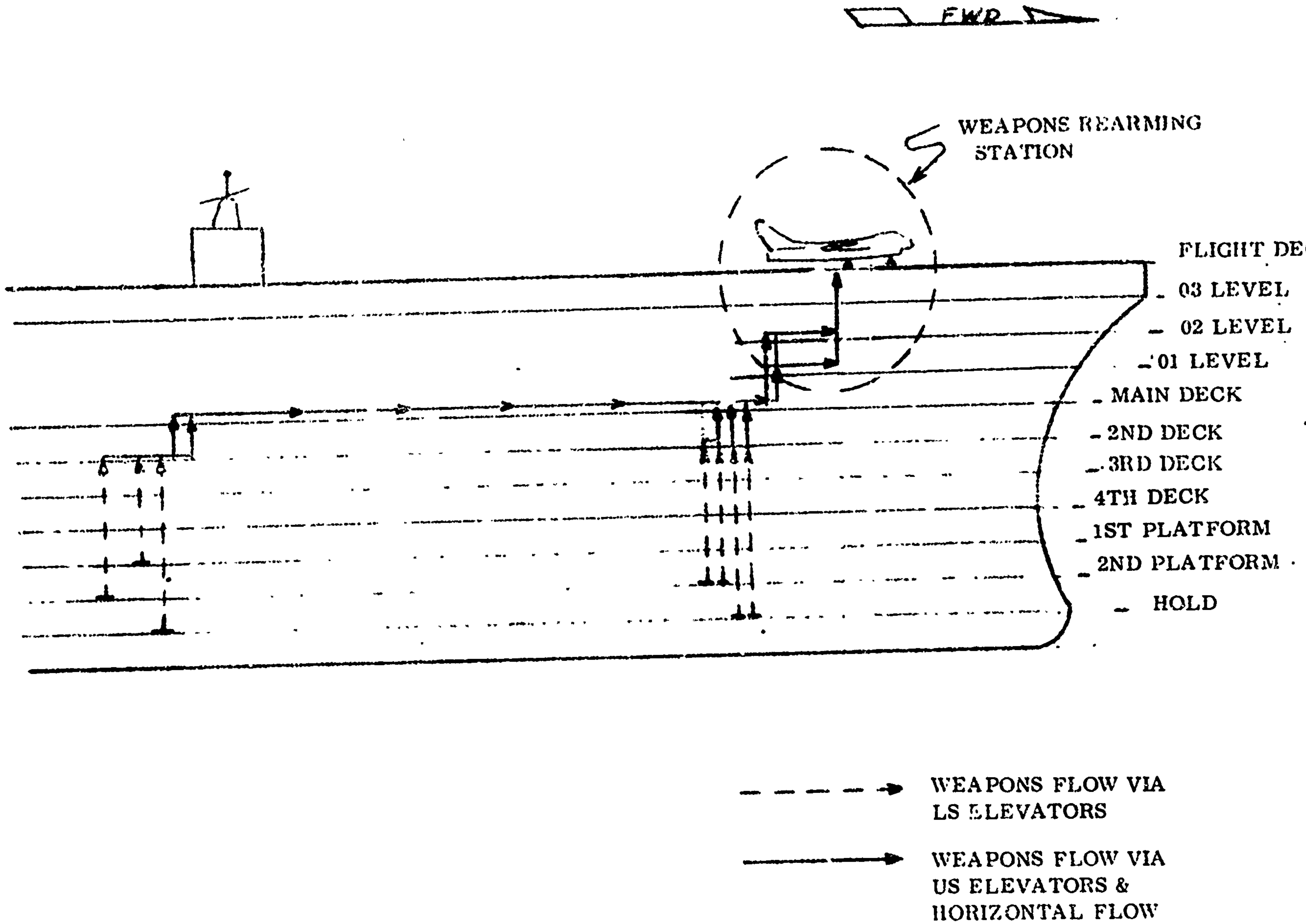


FIGURE 16 GENERAL WEAPONS ON SKIDS FLOW TO WEAPONS REARMING STATION

Ordnance make-up is accomplished in a below deck environment on an assembly line technique with the rearming station. The ordnance flow through the rearming station is standardized for maximum operational efficiency. The rearming station relies upon machine power rather than "muscle power" to load bombs aboard planes. Sensors, control systems and feedbacks are coupled with human flexibility and skills to accomplish ordnance loading.

4. Applicability to Improved Strike-Up Systems

Various systems have been proposed by the Navy for improving the weapon storage and strike-up capability. For example the mechanized weapons handling system planned for the USS Kennedy, CVA-67 will greatly improve weapon strike-up capability and reduce manpower. This system encompasses: conveyors for loading upper stage elevators, an across-the-deck shuttle for transferring weapons from the lower stage (L.S.)elevators to upper stage elevators and computerized controls. Analysis indicates that the unit load rearming station could easily be interfaced with the mechanized weapons handling system. In fact, systems for faster and more efficient weapon strike-up to the main deck would assist in utilizing the full capability of the rearming station.

The rearming station will also assist in standardization and consolidation of weapon handling hardware. For example, the A/M 32K-5(V) Munitions Handling Set (reference 13) now being developed to replace a number of weapon skids/adapters, can easily be used with the rearming

station. Weapons flow from the magazines will be more systematic thus allowing better use of special tools and assembly line techniques.

5. Strike-Up Requirements - Parametric

Parametric data on ordnance strike-up to supply the unit load rearming station to achieve various rearming rates are shown in figures 17 through 20. These curves relate aircraft loading rates, weapon payloads, and strike-up rates; strike-up rates and ordnance elevator cycling rates; strike-up rates and pieces of ordnance handled.

Figure 17 can be used for determining the strike-up rate requirements from the weapons magazine to the main deck or the strike-up rate requirement through the rearming station. For example, the strike-up rate from the main deck for loading one A-7 aircraft each 3.5 minutes with 16,000 pounds of ordnance is 2.3 tons per minute. Operational analysis of the baseline rearming station (Section V.E.) indicates that one rearming station has the capability of loading from 2.0 to 3.0 tons per minute. Consequently, nominal strike-up rates of 2.0 to 3.0 tons per minute will be required unless weapons/skids are stored on the hangar deck. Technical information indicates that conventional CVA strike-up systems can accomplish from one to two and a half tons of ordnance per minute. <u>Therefore, improved strike-up systems will be necessary to utilize the full capability of one or two baseline rearming stations.</u>

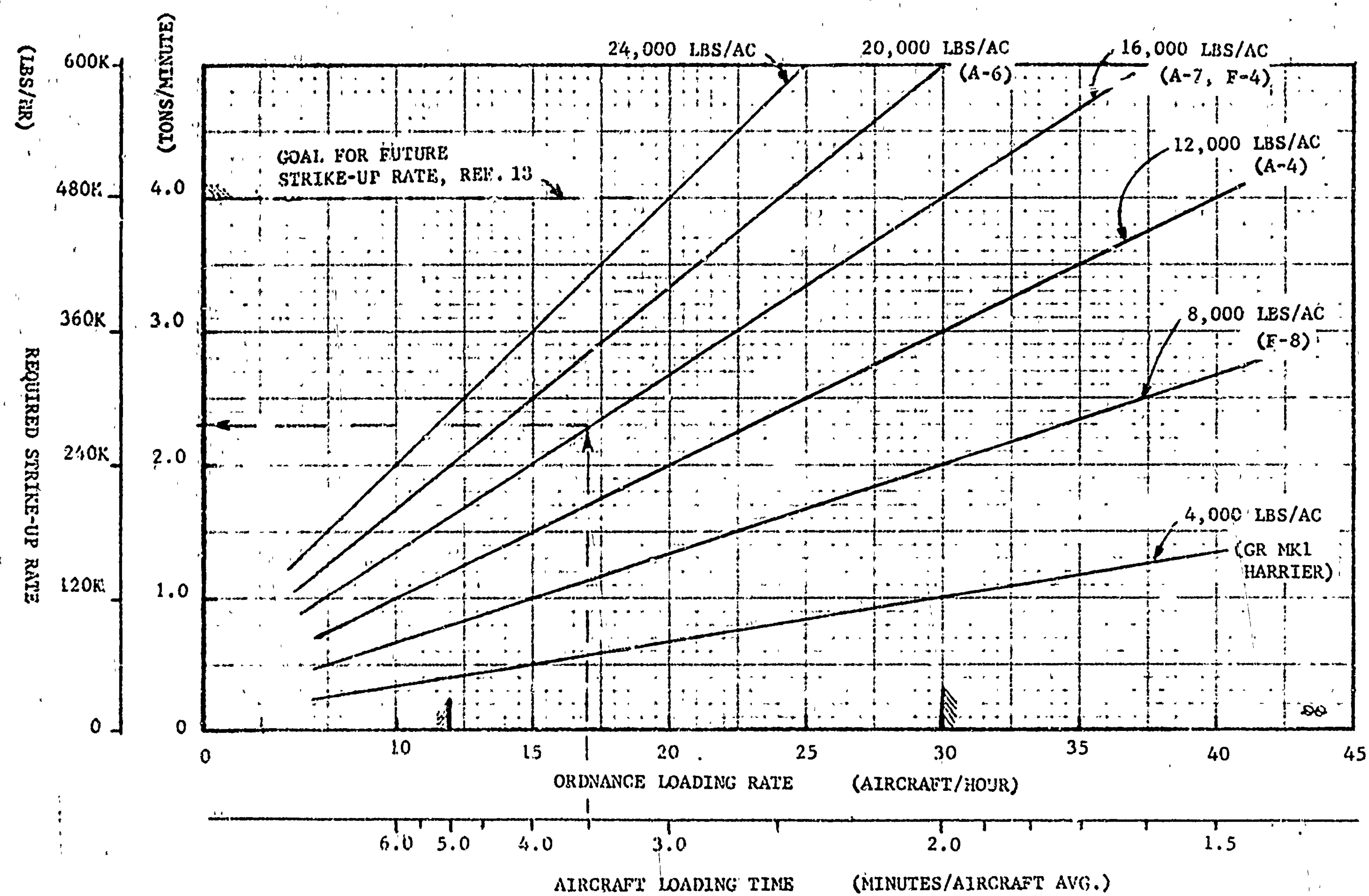


FIGURE 17. REQUIRED STRIKE RATE VERSUS AIRCRAFT LOADING RATE

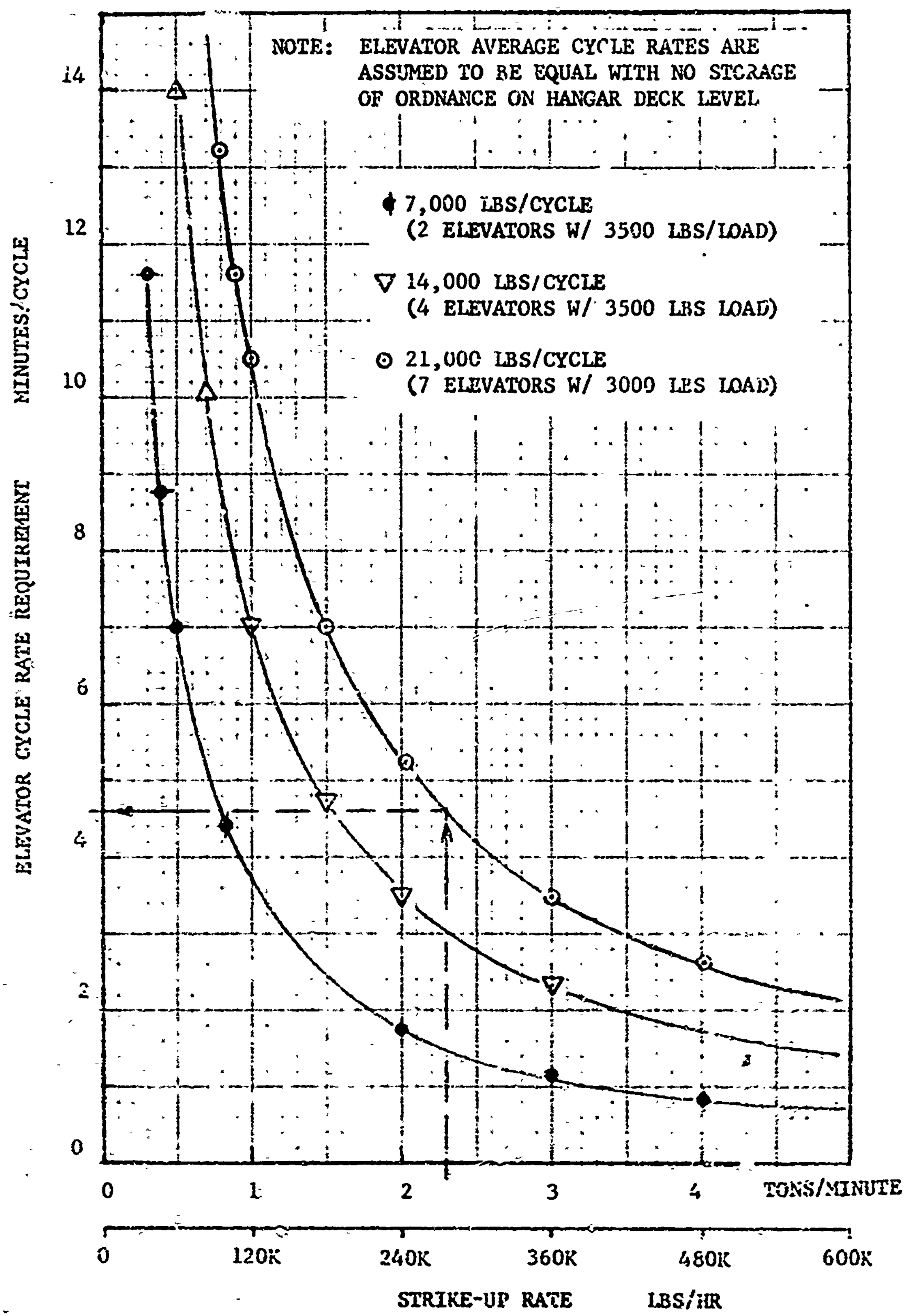


FIGURE 18. REQUIRED ELEVATOR CYCLE RATE VERSUS STRIKE-UP RATE

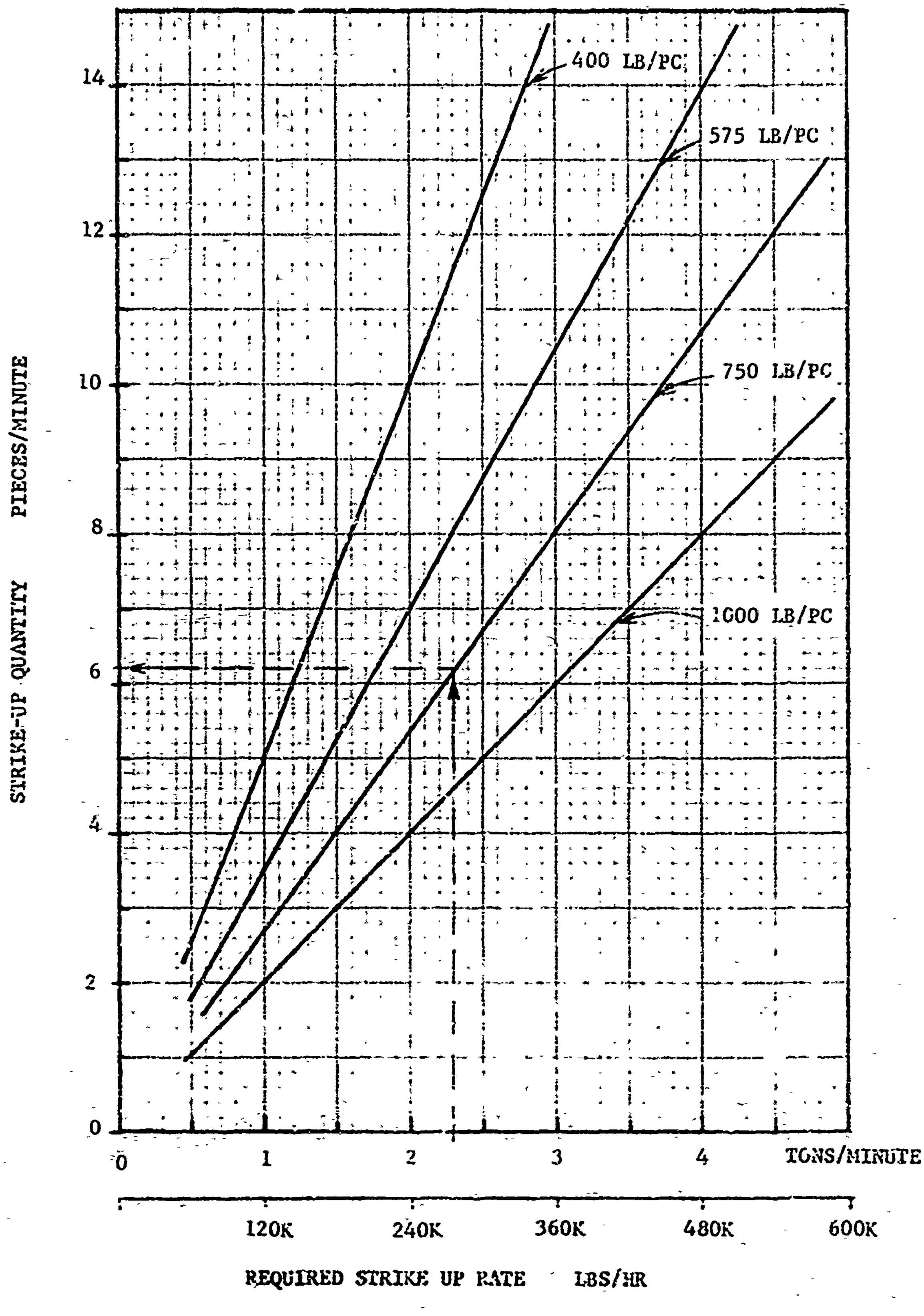


FIGURE 19. STRIKE-UP QUANTITY VERSUS STRIKE-UP RATE

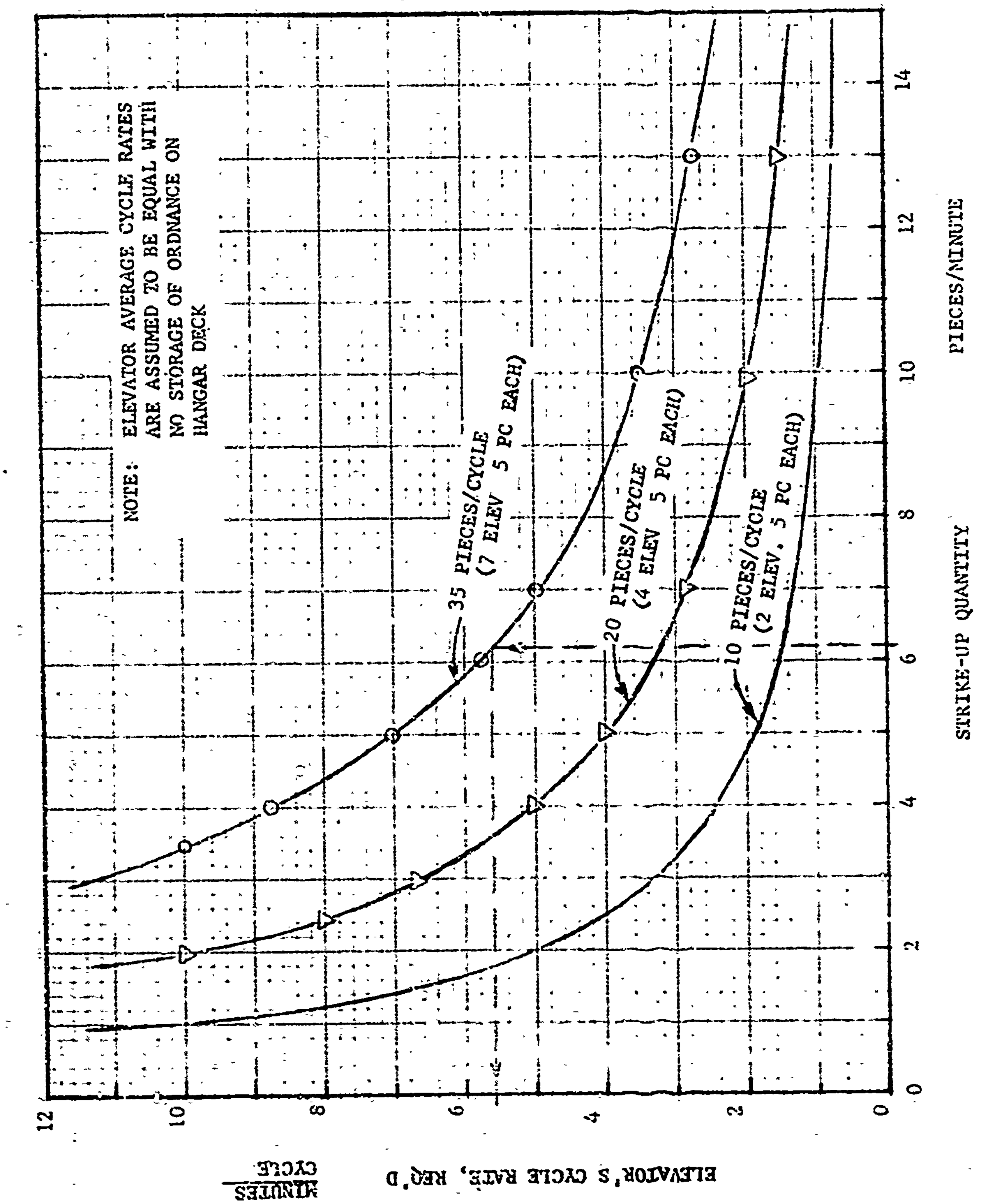


FIGURE 20. REQUIRED ELEVATOR CYCLE RATE VERSUS STRIKE-UP QUANTITY

The average elevator cycle rate capability is a primary variable in conventional strike-up systems. The average elevator cycle rate is limited by inherent design features such as elevator loading rate, elevator speed, communication networks and safety interlocks and elevator unloading rate. Figure 18 presents the necessary average elevator cycle time for various strike-up weight capability and strike-up rate requirements. For example, a required strike-up rate of 2.3 tons per minute using two elevators with a 10,500 pound capacity each requires an average elevator cycle time of 4.6 minutes per cycle.

Required elevator cycle rate to feed the rearming station is constrained by the elevator volume as well as elevator weight capacity. Figures 19 and 20 can be used to approximate the required elevator cycle time based upon elevator volume constraint. For example: a required strike-up rate of 2.3 tons per minute of ordnance which averages 750 pounds per piece results in 6.2 pieces per minute strike-up requirement (figure 19). From figure 20, a 6.2 pieces per minute strike-up requirement, using two elevators with a combined 35 pieces/cycle capability, results in a required elevator cycle each 5.6 minutes average.

6. Ordnance Pallet Make-Up Requirements

Ordnance pallet make-up consists of placing and securing the weapons on the weapon support fixtures and positioning the weapon support fixtures so that the ordnance lifting lug pattern match the bomb rack lug pattern on the aircraft to be loaded. For this study, the following general ordnance pallet make-up requirements were used:

- Desired aircraft loading rate of 1 aircraft each 3 to 4 minutes (reference 13)
- Ordnance flow to main deck, below rearming station, before being fed to make-up areas
- Hardware interference and equipment idle time should be minimum
- System design should provide for inherent reliability, redundancy, and operational safety

7. Ordnance Pallet Make-Up Area Concepts

Various concepts for ordnance pallet make-up area configuration were developed and analyzed. Figure 21 illustrates concept number 1 with two make-up areas outside the rearming station elevator and on the 03 level. This concept has a high degree of flexibility and reliability. The aircraft rearming rate is high because simultaneous operations take place in the make-up areas without tying up the rearming station elevator.

Concept Number 2, figure 22, is one in which ordnance load make-up is accomplished on the elevator. Because of the slow loading time and limited flexibility this concept was considered less optimum for the CVA class ships, than the two independent make-up area concepts.

Concept Number 3, figure 23, is one in which ordnance pallet make-up is accomplished on the main deck. The attractive feature is that the outboard upper stage (U.S.) elevators are eliminated. However, this concept uses valuable area on the main deck level for pallet make-up and requires an overhead hoist for pallet make-up.

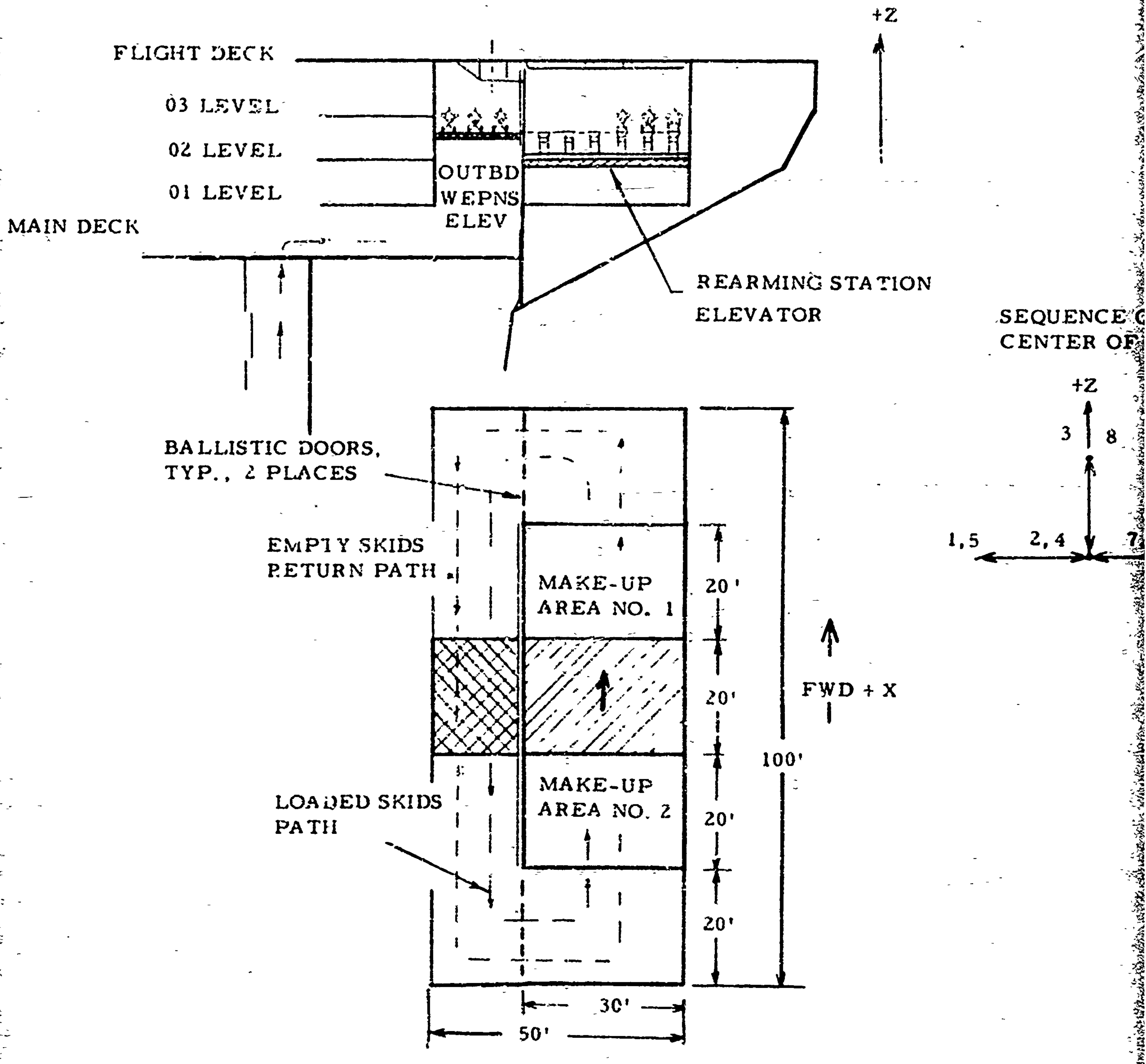
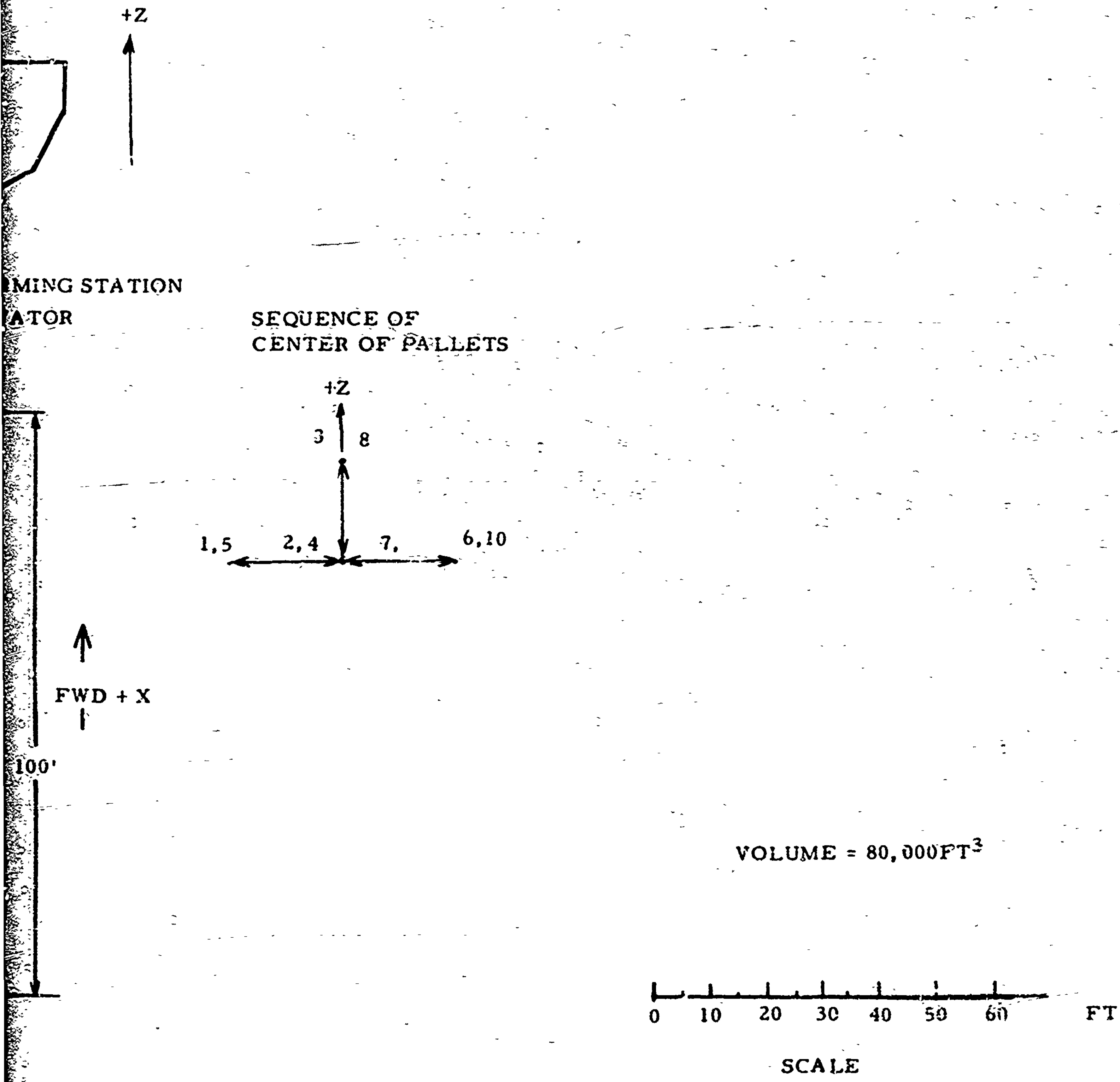


FIGURE 21. CONCEPT NO. 1 - PARALLEL ORDNANCE MAKE-UP



PARALLEL ORDNANCE MAKE-UP ON 03 LEVEL

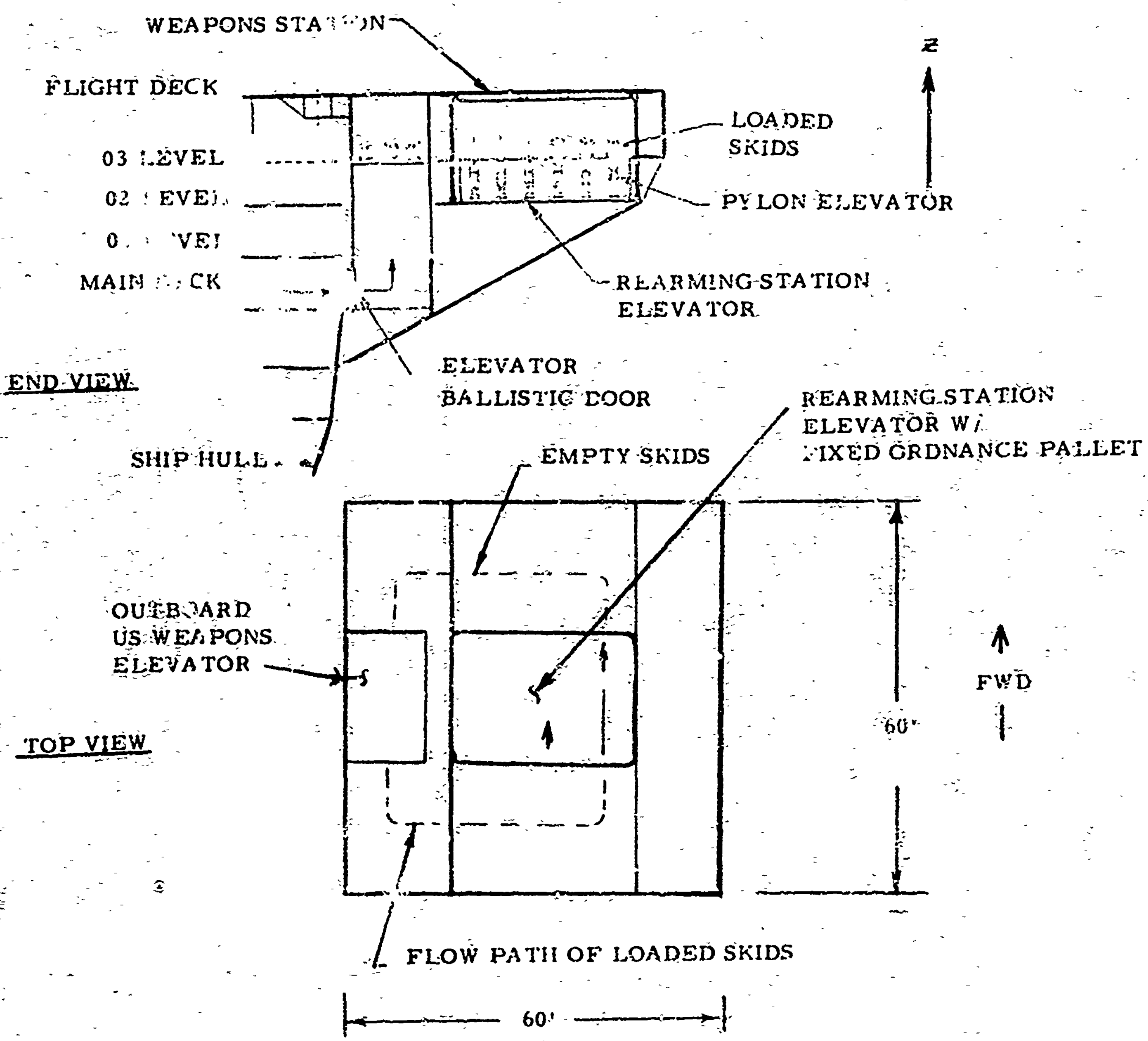
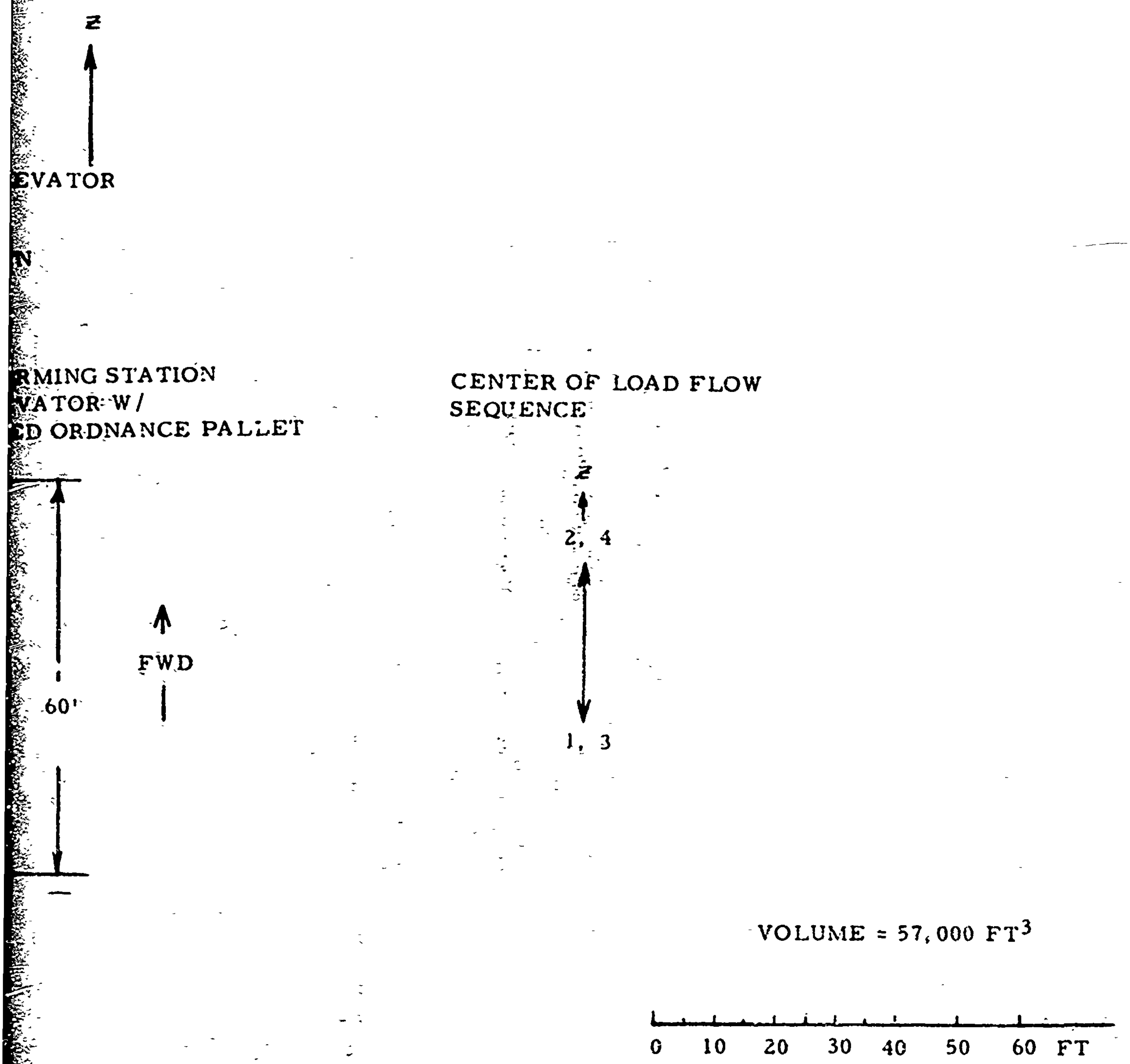
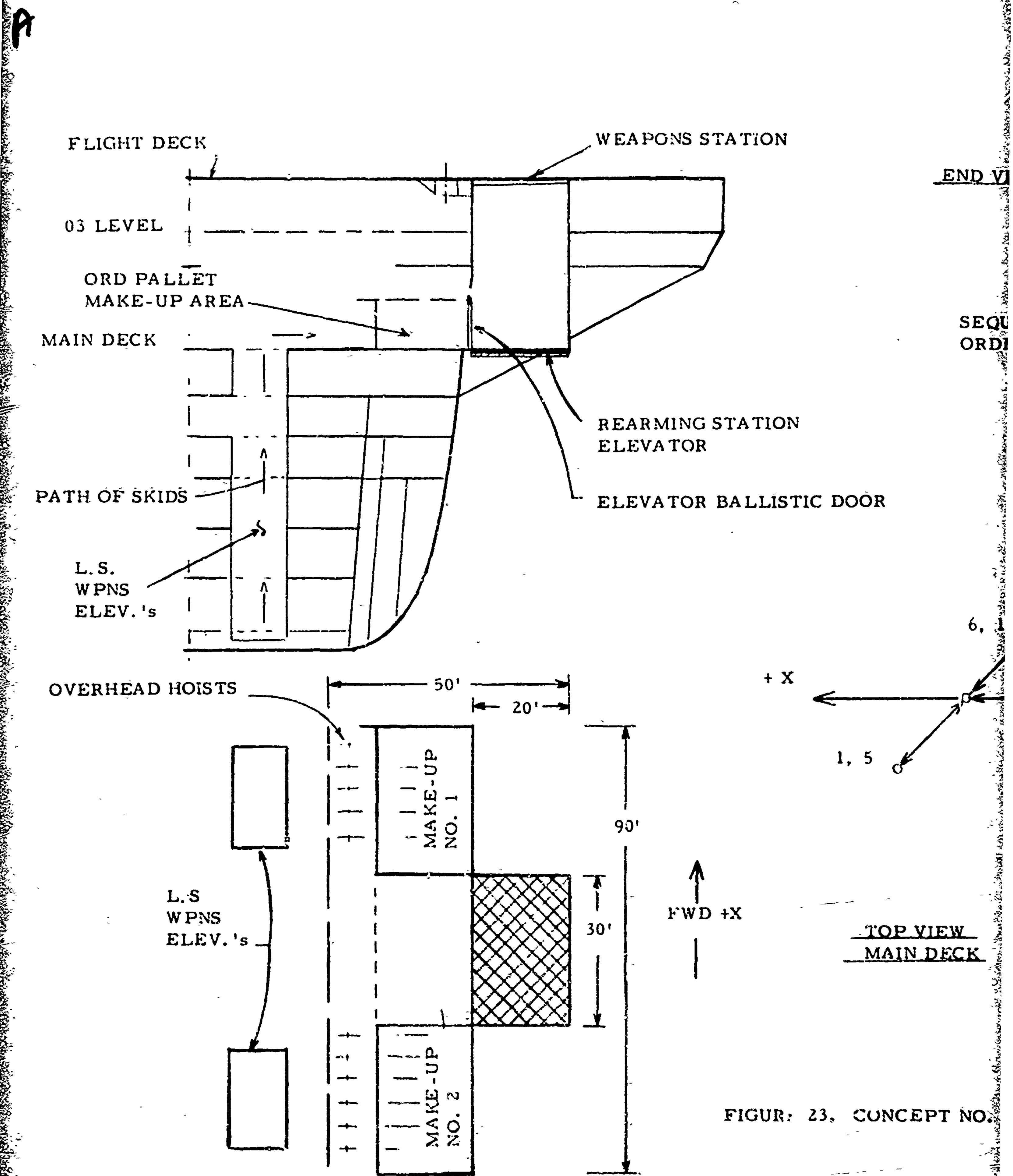


FIGURE 22. CONCEPT NO. 2 - ORDNANCE MAKE-UP ON



– ORDNANCE MAKE-UP ON ELEVATOR 03 LEVEL



FIGUR: 23. CONCEPT NO.

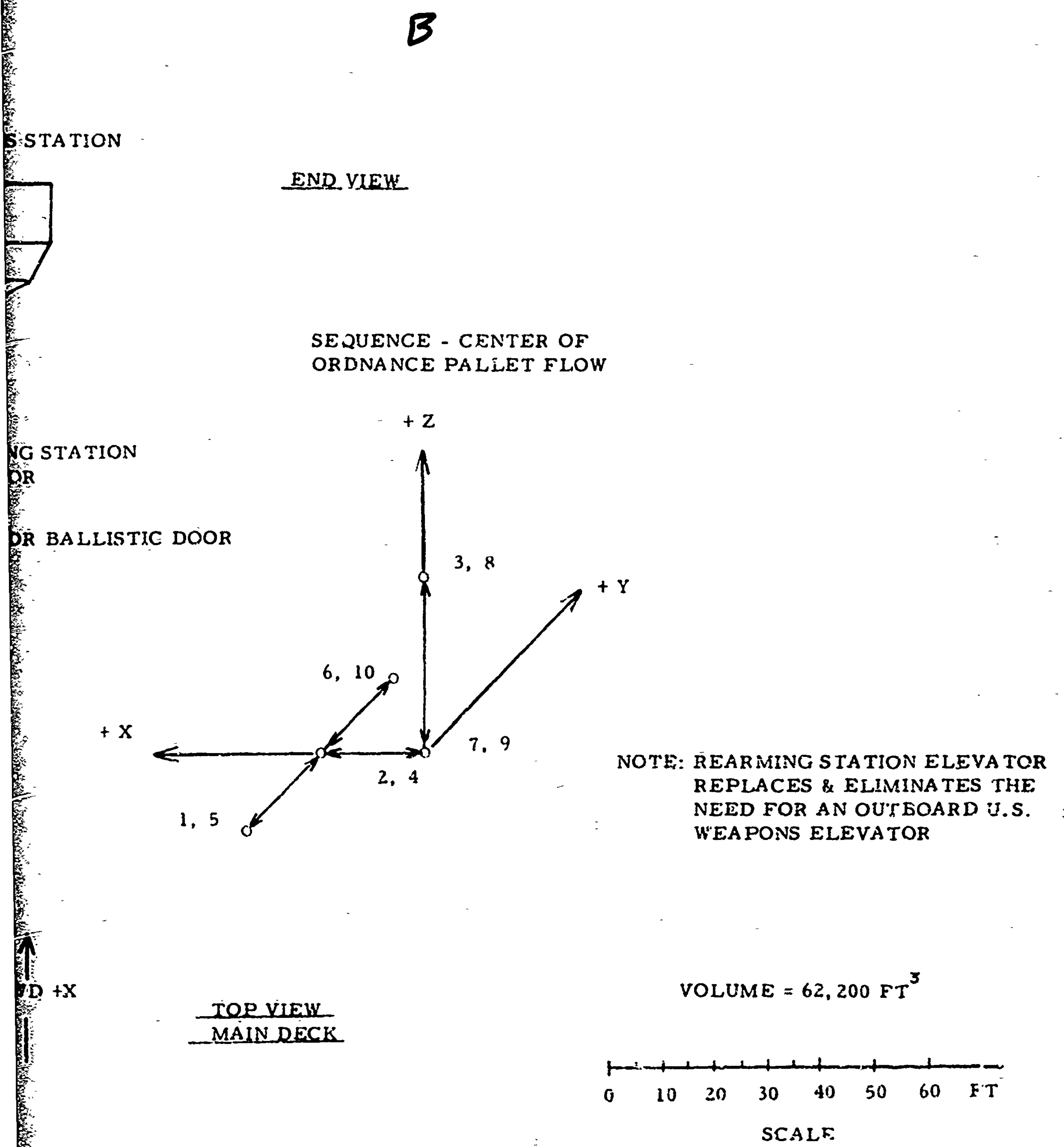


FIGURE 23. CONCEPT NO. 3 - PARALLEL ORDNANCE PALLET MAKE-UP ON MAIN DECK

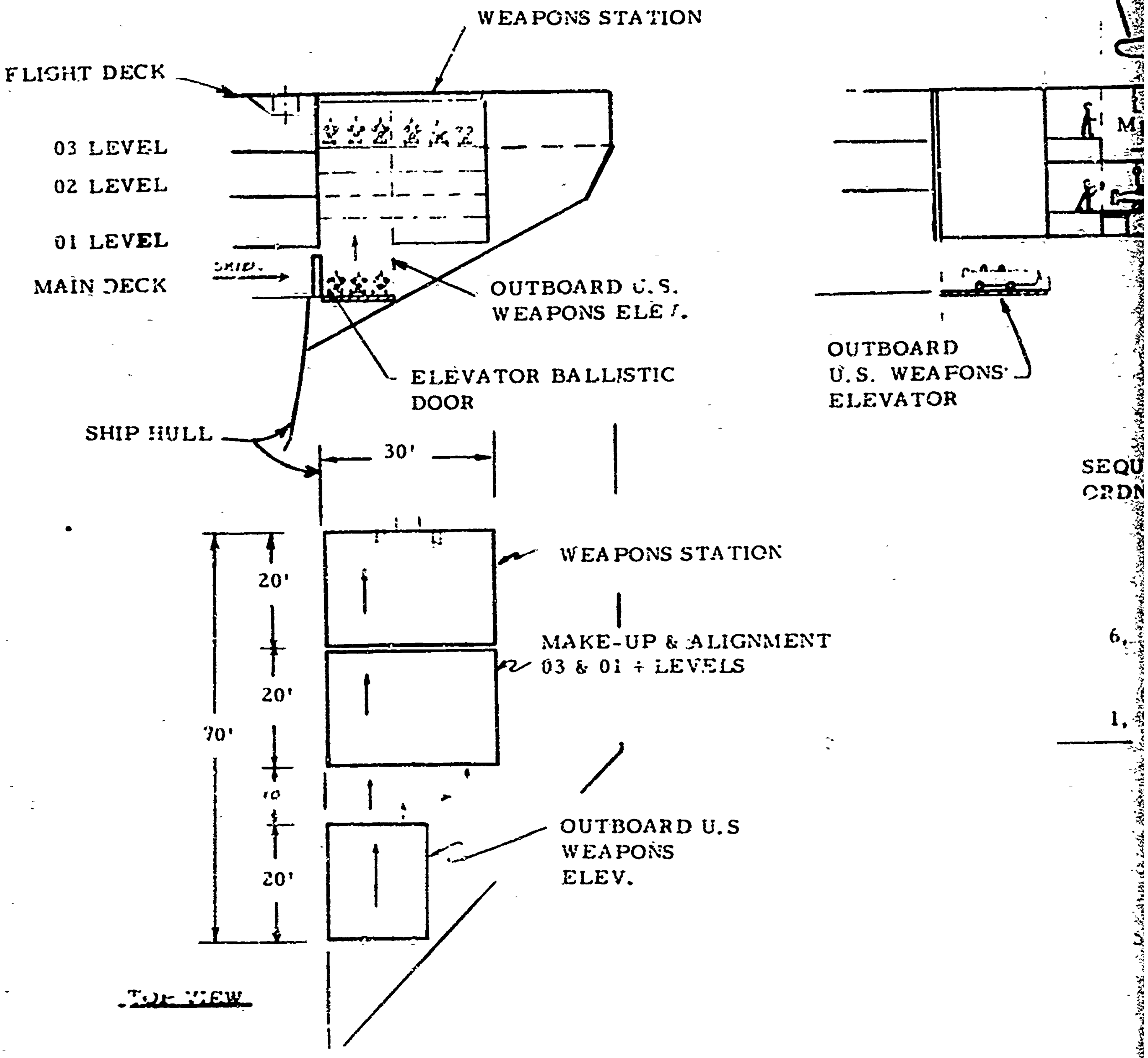
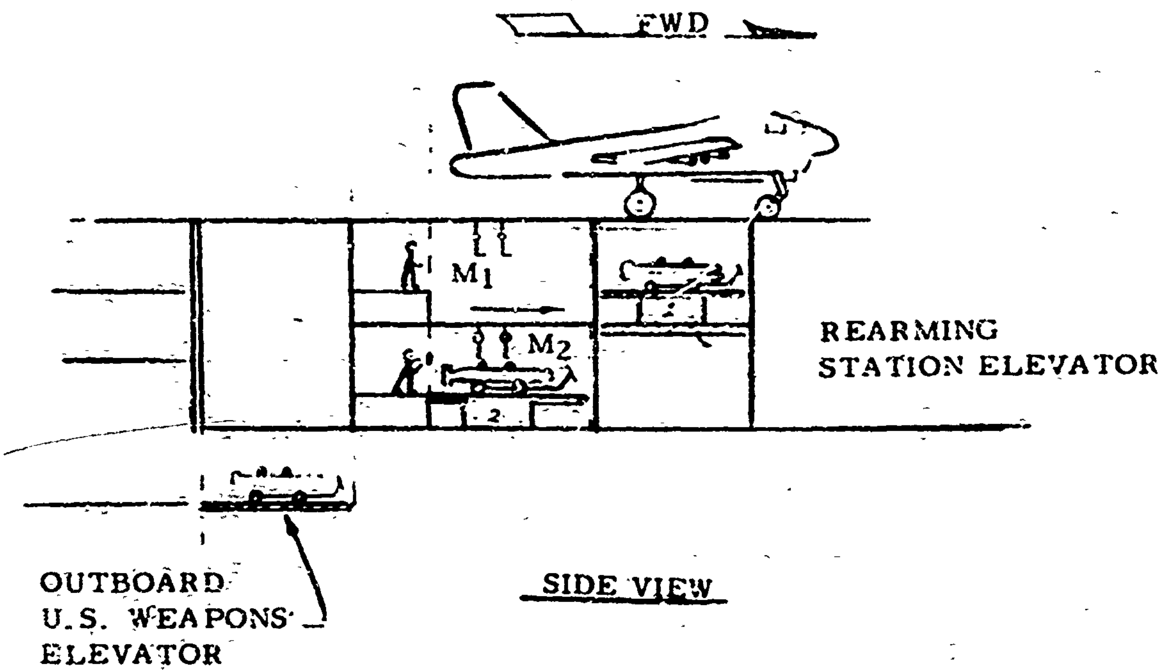


FIGURE 24. CONCEPT NO. 4 - ORDNANCE PALLET MAKE-UP ON T

B



SEQUENCE - CENTER OF
ORDNANCE PALLET FLOW

ON

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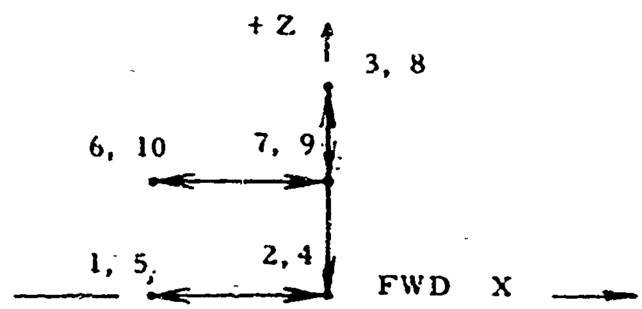


VOLUME = 51,000 FT^3

0 10 20 30 40 50 60 FT

SCALE

DNANCE PALLET MAKE-UP ON TWO LEVELS

Concept Number 4, figure 24, provides ordnance make-up areas on two different levels. The bi-level make-up area concept has all of the advantages of concept number 1. The added feature is one of improved operational safety and redundancy because the make-up areas are on different levels, separated by ship structure. Results of a small mishap such as a smoking heater in one make-up area would not interefere with operations in the other area.

Based upon a comparison of make-up rearming station volume, cycle time, operational performance and flexibility a two level make-up station was selected for further analysis during this phase study.

D. GENERATION OF SYSTEMS HARDWARE CONCEPTS

1. Introduction

Based upon the requirements and concepts generated in Section V-B, a rearming station concept was selected for hardware definition. This section describes the baseline rearming system and discusses hardware concepts for the station and associated subsystems. An interface diagram and a total station configuration drawing describe the subsystem interfaces and, together with requirements data sheets, form the nucleus of a set of hardware specifications for the rearming station.

Projected performance data for rearming time and manpower are presented for the baseline system.

2. Total Station Configuration

The baseline two-pass rearming concept presented and discussed in Section V-B was selected for systems hardware definition.

This selection was based on several factors, the most prominent being manpower, time, ship volume, operational flexibility and reliability.

The total station configuration is shown in figure 2. The concept is discussed in detail in Section V-B and only a brief description of the major features will be reiterated.

The station consists of four main areas: upper stage (U.S.) ordnance elevators, holding ramp, weapons pallet make-up and alignment, and the loading station. The below deck space is divided into two levels, one at the 01 level and the other between the 02 and 03 levels. The bilevel division of the below deck space offers several operational advantages, notably the orderly and smooth flow of weapons and skids from the main deck to the rearming station, and the capability of simultaneously performing weapons pallet make-up/alignment and weapons loading. In addition, the bilevel arrangement provides a back-up system in the event of failure on upper stage elevator or equipment in the make-up area.

The two ordnance elevators serve either the upper or lower make-up level and are sized to carry three fully loaded weapons skids each. The ordnance elevator cycling is independent of the rearming station elevator since weapons pallet preparation is done in the make-up area. The holding ramp provides a skid loading/unloading area to free the elevator from waiting until a weapons pallet is available before offloading. This independency of functions lends a good deal of flexibility and

versatility to the system. For example, it is possible to "prime" the system prior to aircraft loading by having one aircraft load ready on the rearming station elevator, a second load ready on the weapons pallet in the make-up area, and a partial third load waiting on the upper stage elevators for movement onto the weapons support fixtures as empty skids are off loaded.

A key component of the baseline rearming system is the weapons pallet. The pallet permits the shuttling of the prepared total weapons load from the make-up area to the rearming station elevator and provides a reference datum for weapons alignment. Movement of the pallet from the make-up area to the rearming station elevator is by air bearing modules and guide rails. The low frictional resistance provided by the air bearings minimizes the motive force required to shuttle the pallet back and forth from the make-up area to the rearming station elevator. Two weapons pallets allow weapons make-up and alignment operations to take place concurrently with weapons loading.

The rearming station elevator shuttles the weapons pallet between the aircraft and the two make-up levels. The elevator is sized for the largest weapons load encountered in two-pass loading, and the heaviest weapons load carried by the A-6 aircraft. The rearming station elevator also serves as a reference datum for positioning the weapons pallet in relation to the aircraft.

Aircraft positioning and support over the loading station is by main gear support beams, adjustable for various aircraft wheel tracks, and a nose gear bridge. The beams have been sized to support the maximum take-off weight of the A-6 aircraft and to withstand shock loads imposed on the station. The preliminary design calculations are presented in the Appendix. The depth of the aircraft structural support is a critical dimension in the design of the station since it determines the maximum height to which the weapons pallet can be raised. From the preliminary analysis, it was determined that the depth of the main gear support beams and nose gear bridge is 30 inches and 16 inches, respectively. Allowing two inches for detailing and connections, a total distance of 48 inches is used for the aircraft support system.

Detailed discussions of the rearming station subsystems are presented in Section V-D.5.

3. Interface Diagram

Figure 25 illustrates the major subsystems and interfaces for the rearming station. This diagram, when related to the total station configuration drawing, figure 2, and to the requirements data sheets, describes the hardware items within the rearming system. The diagram shows the structural and functional relationships of the rearming station subsystems, and the ship system/weapon station interfaces.

Each rectangular block on the diagram represents a major hardware item or function, and is identified by a three-digit number.

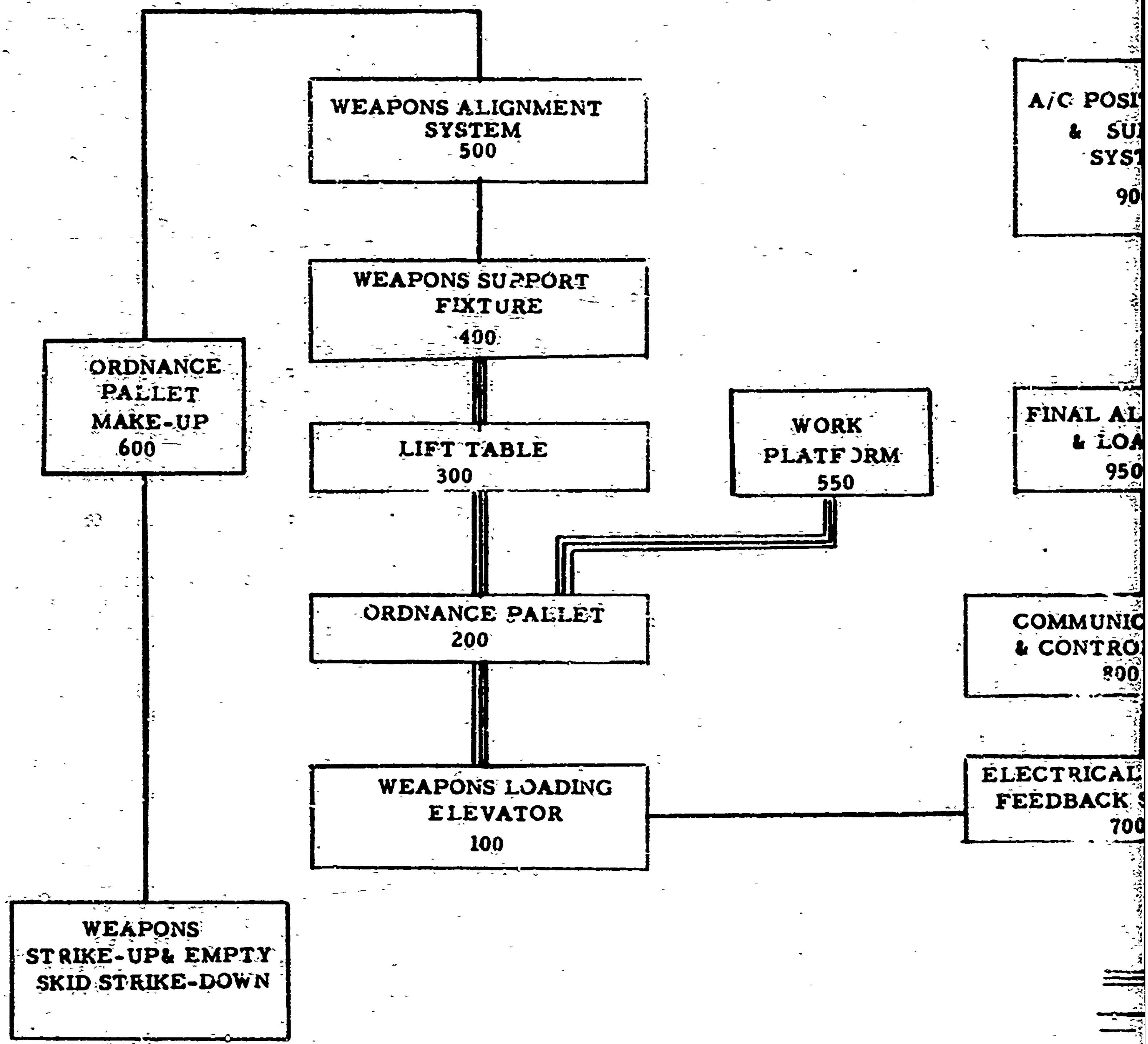
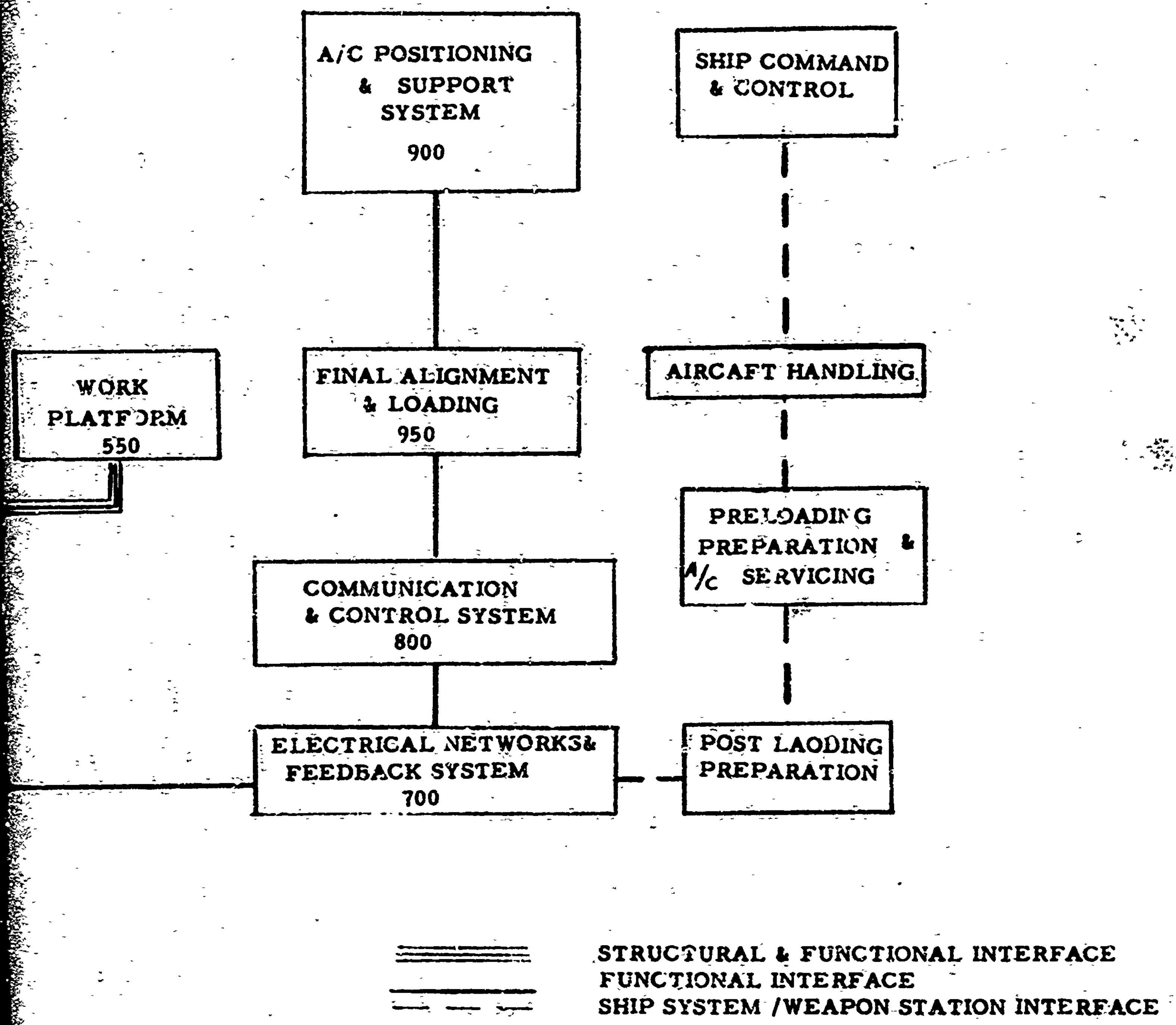


FIGURE 25. WEAPONS LOADING STATION INTERFACES

B



DING STATION INTERFACES

This number corresponds to the item number shown on the baseline concept drawing, figure 2, and on each of the requirements data sheets. The baseline concept drawing, interface diagram and data sheets serve as a nucleus for a hardware specification package, which can be updated as each hardware item is more clearly defined.

4. Requirements Data Sheets

For the major hardware items composing the rearming station, a data sheet has been generated to define the requirements and give a brief description of the item. Wherever possible, an off-the-shelf item has been described, even though Navy requirements may later necessitate redesign of the item. The primary purpose of generating the data sheets is to show that hardware providing similar requirements is available or within the present state-of-the-art, and to assist in identifying long-lead development items.

5. System Definition

a. Aircraft Support

The aircraft is supported over the rearming station by two longitudinal beams, which are adjustable for the aircraft main gear wheel track, and a nose gear bridge. The main gear wheels rest on movable pads attached to the longitudinal beams and the nose gear bridge provides the motive force for towing the aircraft over the station. After loading, the aircraft is towed from the station by tow tractor.

REQUIREMENTS DATA SHEET	PAGE 1 of 1	
ITEM: ORDNANCE PALLET NO. 201	DATE 1/21/72	REV.

1. DESCRIPTION

The Ordnance Pallet provides a rigid base for mounting the weapon support fixtures and serves as a shuttle for moving the weapons from the make-up area to the ordnance loading elevator. The Ordnance Pallet is the key to accomplishing unit or simultaneous loading since it establishes a datum for weapons alignment. When the weapons have been positioned and aligned on the pallet, then the pallet needs only to be aligned with reference to the aircraft either automatically or semiautomatically to accomplish mating and latching.

The pallet is mounted on a low friction, air bearing-guide rail system to reduce the motive force required to move the total weapons load from the make-up area to the rearming station elevator. The pallet and rail system incorporate brakes and locks to secure the pallet at any position along the length of the rails.

The Ordnance Pallet is designed to accomodate the total weapons load of the A-4, A-6, and A-7 aircraft. The F-4 and similar large aircraft will require two partial loads to completely rearm all stations.

2. SPECIFIC REQUIREMENTS

a. The Ordnance Pallet should be structurally capable of supporting a total load of approximately 50,000 lbs. (Section V-B.2.b)

b. The pallet should weigh not more than 5000 lbs.

c. Size is approximately 32 feet by 16 feet (Section V-B.2.b).

REQUIREMENTS DATA SHEET		PAGE 1 of 2	
ITEM: LIFT TABLE	NO. 300	DATE 1/21/72	REV.

1. DESCRIPTION

The Lift Table serves as a stable platform for the weapons support fixture and provides the capability of positioning the weapons at the proper height for loading. The Lift Table is mounted on a low friction ball bushing-rail system which enables it to be positioned at any location laterally and longitudinally on the weapons pallet.

2. GENERAL REQUIREMENTS

The Lift Table must meet the following requirements:

- Support a fully loaded AERO-21A skid and Weapons Support Fixture or a fully loaded A/M 32K-5(V) Munitions Handling Set (presently being developed) and the Weapons Support Fixture.
- Provide the capability of raising and lowering the Weapons Support Fixture and loaded skid to the proper loading height.
- Provide the capability of positioning and locking the Weapons Support Fixture at any point longitudinally and laterally on the weapons pallet to coincide with the aircraft weapon station location.

3. SPECIFIC REQUIREMENTS

a. Load capacity: 8000 lbs (Section V-B.2.b)

b. Maximum vertical travel: 62 inches (Sect V-B.2.c)

c. Collapsed height: 14" (max.)

d. Extended height: 76" (max.)

e. Platform size: 30" wide x 72" long

f. Frame size: 30" x 72"

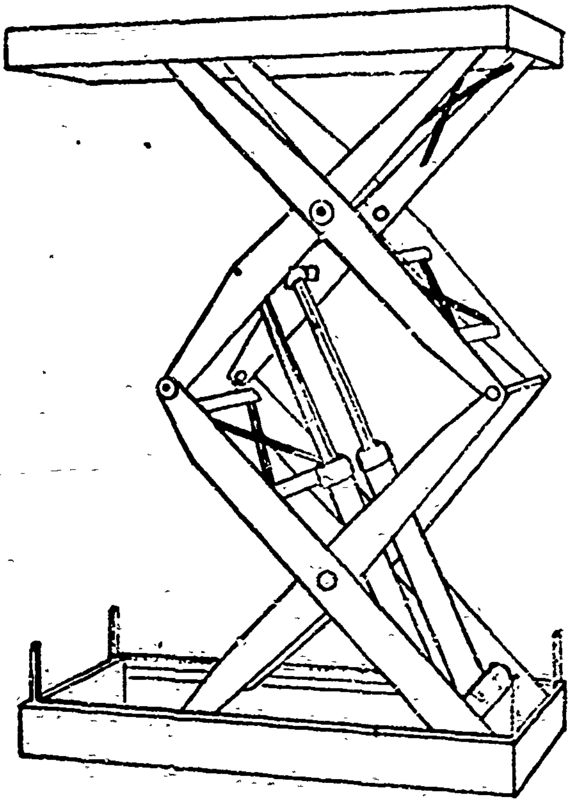
g. Motor: 3 H.P. electric

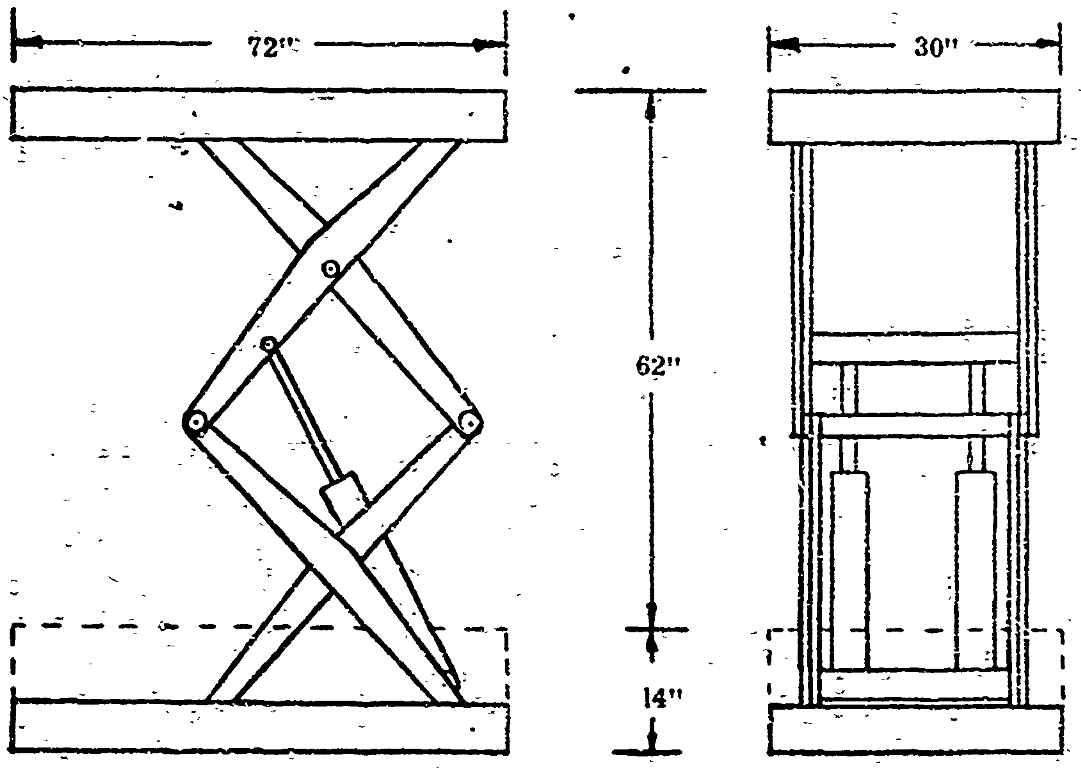
h. Power Source: 220/440 volt, 60 cycle, 3 phase

i. Alternate power: Air motor

j. Approximate weight: 2000 lbs.

k. Rise time: 43 sec (fully loaded)





LIFT TABLE
(300)

REQUIREMENTS DATA SHEET	PAGE 1 of 2	
ITEM: WEAPONS SUPPORT FIXTURE NO. 400	DATE 1/21/72	REV.

1. DESCRIPTION

The Weapons Support Fixture is one of the most important systems of the unit load rearming station for carrier based aircraft. This fixture must

- Secure and support ordnance from ordnance pallet make-up through weapons loading.
- Provide for necessary adjustments in pitch, yaw, roll and horizontal translation to make final aligament of a wide variety of weapons to carrier based aircraft.
- Support and secure empty weapon skids from weapons loading until the skids are removed from the ordnance pallet.

2. SPECIFIC REQUIREMENT

The Weapon Support Fixture must meet the following requirements:

a. Structurally support a 5000 pound fully loaded Aero 21A skid and associated weapons adapters or a 5000 pound fully loaded A/M 32K-5(V) Munitions Handling Set, presently being developed.

b. Provide capability for rapidly moving a supported weapon as follows:

Pitch: +10 degrees, -7 degrees

Yaw: $\pm$2 1/2 degrees

Roll: $\pm$7 degrees (Section V-B. 2. c)

Forward and Aft ($\pm$x) travel: $\pm$4 inches

Lateral Translation ($\pm$y) travel: $\pm$2 inches

These adjustments must be made independent of the lift table, ordnance pallet and weapon loading elevator adjustments.

c. Mechanisms for moving the supported weapons shall be manually actuated with the capability of upgrading to a fully automated system.

d. The Weapon Support Fixture must have the capability for mounting onto a lift table which is 30 inches wide and 72 inches long.

e. Maximum height of fixture from skid floor to top of lift table is 18 inches.

f. Maximum width - 30 inches.

REQUIREMENTS DATA SHEET		PAGE 2 of 2
ITEM: WEAPONS SUPPORT FIXTURE NO. 400	DATE 1/21/72	REV.

g. Maximum length - 72 inches

h. Maximum weight - 1000 lbs.

In addition to the above requirements this fixture shall be rugged, reliable and easy to operate and maintain under aircraft carrier environments.

REQUIREMENTS DATA SHEET	PAGE 1 of 1	
ITEM: WEAPONS ALIGNMENT FIXTURE NO. 500	DATE 1/21/72	REV.

1. DESCRIPTION

The Weapons Alignment Fixture is used to align the weapons on the weapons pallet such that the weapons/suspension lugs coincide with the aircraft EBR hook pattern. When this alignment is accomplished, the weapons are ready for latching onto the aircraft without additional adjustments. The fixture may be manual or automatic, however, a computer controlled fixture, similar in operation to an X-Y plotter or numerically controlled machine, offers many operational advantages. With a computer controlled fixture, aircraft variables, such as tire pressure, fuel load and manufacturing tolerances, can be accounted for in the alignment.

The alignment fixture operates as follows:

- Data for the aircraft ejector bomb rack (EBR) hook locations and the weapons suspension lugs positions are input. If the fixture is manually operated and controlled, the data is used to set the position of the simulated EBR hooks to coincide with the EBR hooks on the aircraft to be loaded. For a computer controlled fixture, the data activates drive systems which automatically position the simulated EBR hooks.
- The Weapons Alignment Fixture is placed on the weapons pallet and the lift table and weapons support fixtures adjusted until the weapons lugs and simulated EBR hooks mate.
- The weapons support fixtures are locked into place and the alignment fixture removed.
- The weapons pallet is moved to the elevator for loading onto the aircraft.

2. SPECIFIC REQUIREMENTS

The Weapons Alignment Fixture must meet the following requirements:

a. Provide capability of aligning the weapons lugs to within $\pm 0.1''$ in fore, aft and lateral directions, and to $\pm 1/2^{\circ}$ of the EBR hook centerline in pitch, roll and yaw angles.

b. The maximum depth of the Alighment Fixture, with all simulated EBR hooks retracted, should not be greater than 18". Maximum width and length should not exceed 32' and 17', respectively.

REQUIREMENTS DATA SHEET	PAGE 1 of 1	
ITEM: WORK PLATFORMS NO. 550	DATE 1/21/72	REV.

1. DESCRIPTION

The Work Platforms provide access to the weapons support fixtures and the aircraft weapon stations during rearming. The platforms are basically personnel lifts which can be raised and lowered to the desired working level. The platforms are mounted on the Lift Table rail system and can be positioned at any location directly forward of the Lift Table. The Work Platforms can be controlled remotely in the vertical direction. The lateral and longitudinal position is established and the Work Platforms locked into place prior to being manned.

The Work Platforms, in addition to being used for ordnance loading, could also serve as access platforms for aircraft servicing and for maintenance of the aircraft support system.

2. SPECIFIC REQUIREMENTS

The Work Platforms should meet the following requirements:

a. Provide a work platform 34" wide x 60" long. Removable, lightweight grating extensions should provide a capability of extending the platform width to 64" and length to 108" long.

b. Vertical travel capability: 36"

c. Extended height: 42" (max.)

d. Collapsed height: 6"

e. Capacity: 2000 lbs.

f. Motor: 1 HP (electric)

g. Power Source: 110 volt, single phase 60 cycle

h. Rise time: 22 seconds

i. Approximate weight: 600 lbs

The aircraft support system is sized to support a total load of 60,626 lbs, which is the maximum take-off weight of the A-6 aircraft. The A-6 represents the maximum weight condition of the four aircraft considered in this study. Shock loading requirements, outlined in reference 14, were included in the preliminary analysis of the aircraft support system. From the preliminary analysis, it was determined that the main gear beams will require an elastic section modulus of 240 in^3, and the nose gear bridge will require 209 in^3. These values are based on the length (38'-6") and width (32') of the single pass station. With the two-pass baseline station concept, the main gear beam length is reduced to 28'-9" and the section modulus requirement will be greatly reduced. The nose gear bridge length does not change, consequently, the beam size will remain the same. Since the primary purpose in sizing the aircraft support system is for weight estimation, the most conservative condition, the single pass station length, is used.

For the main gear beams, a standard structural steel section, 30 WF 99, is used. The steel is assumed to be ASTM A242, A440 or A441, with a yield point of 50,000 psi. For the nose gear bridge, a box-section made up of 1/2" thick structural steel plates is used. Based on these support members, the aircraft support system weight for the single-pass station concept is approximately 14,000 lbs. For the two-pass concept, the weight can be reduced to

approximately 12,000 lbs, assuming the same beam size as for the single pass concept.

The aircraft support system impacts the weapons pallet and weapons support fixture design since the depth of the support beams determines the maximum height to which the weapons pallet can be raised. The difference in the height between the weapons pallet and the hook height of the aircraft must be designed into the weapons support fixtures. For this reason, the maximum depth of the aircraft support beams, which results from the single pass station, is used as a baseline aircraft support system parameter.

Calculations for the aircraft support system beams are given in the Appendix.

b. Weapons Pallet

The weapons pallet provides a rigid platform for supporting and moving the aircraft weapons from the unit load make-up area to the aircraft. The platform is built up of steel plates and rectangular tubing stiffeners. The top of the weapons pallet is equipped with a crisscross pattern of rails to provide lateral and longitudinal movement of the weapons support fixtures. The lateral direction rails are fixed to the pallet platform. The three longitudinal rails, located under each weapon support fixture, are equipped with low friction ball bushing which ride the lateral rails and enable the weapon support fixture and support rails to be moved laterally. Longitudinal

movement of the weapons support fixture is obtained by ball bushings between the weapons support fixture and the longitudinal rails.

The longitudinal and lateral rail system is preliminarily sized for a maximum load of 8000 lbs per weapon support fixture and a travel life in excess of two years. Shock loads have not been considered in selecting rail sizes. The rail shafts are preliminarily sized at 2 1/2 inches in diameter and the bushings are 3 3/4 inches in diameter for the static load condition. The rail and bushing system offer a very low coefficient of friction, approximately 0.001 to 0.004.

The rails and ball bushings are hardware items currently available and have proven performance and reliability. Therefore, very little hardware development is foreseen for the weapons pallet.

c. Computer Controlled Weapons Alignment Jig

After the weapons are positioned on the weapons pallet, adjustments are made so that the weapons will be in the proper orientation for loading onto the aircraft. A mechanical means of doing this alignment in a fast, accurate manner is to utilize a computer controlled weapons alignment jig. The jig will be an electro-mechanical device, similar in operation to an X-Y plotter, which will position simulated bomb racks at the proper locations to duplicate the aircraft EBR's hook pattern. For the specific aircraft and weapons to be loaded, a set of digital data will be input to the alignment jig and

this data will be converted to analog signals which control the various motors and drive systems to position the alignment plates at the correct X, Y, and Z-distances and the correct pitch, yaw, and roll angles.

Once the alignment jig plates have been positioned, the weapons support fixtures are adjusted until the weapon lugs mate with the simulated bomb rack hooks on the alignment jig plates. The weapons pallet is then moved to the elevator, raised to the aircraft and the weapons mated and latched.

Using the alignment jig, mating is assured (provided relief is given in the close tolerances between the suspension lugs and the EBR hooks) after the weapons pallet is raised to the flight deck, thus eliminating needless adjustments on the flight deck where time is critical and where environmental conditions may not be conducive to accomplishment of alignment, mating and latching. The alignment jig will also reduce the effort required in making up the skid loads and the pallet loads since it will not be necessary to position the weapons accurately on the skid or to position the skids accurately on the weapons support fixtures. The total misalignment buildup from the weapon-skid, skid-weapon support fixture, and weapon support fixture-pallet can be corrected by one alignment check and adjustment with the alignment jig.

The alignment jig will permit weapons alignment for any type aircraft or weapons mix and can be programmed to compensate for such aircraft variables as tire pressure, fuel load and manufacturing tolerances. Once the aircraft weapon stations have been accurately located, this data can be used repeatedly to set up the alignment jig and position the weapons for loading.

A feasible concept for a computer controlled weapons alignment jig is shown in figure 26. The alignment jig is stored in the overhead space above the make-up area when not in use. When a weapons pallet is prepared for loading, it is moved on the support rails to an alignment spot directly underneath the jig. The jig is lowered until the four conical legs engage the support posts. The posts are accurately located in reference to the pallet and serve as a datum for the alignment. The aircraft BUNO number, weapons load and other pertinent data, such as tire pressure, fuel load, etc. is entered into the computer which controls the jig. This data generates signals to position the alignment assembly and alignment plates for each weapon station and duplicates the position of the EBR hook pattern for the aircraft to be loaded. The Y-direction movement is obtained by moving the entire assembly laterally and the X-direction is obtained by moving the alignment head fore and aft. The Z-direction adjustment is accomplished by an extendible tube. An alignment plate is mounted on the end of the extendible tube to provide

A

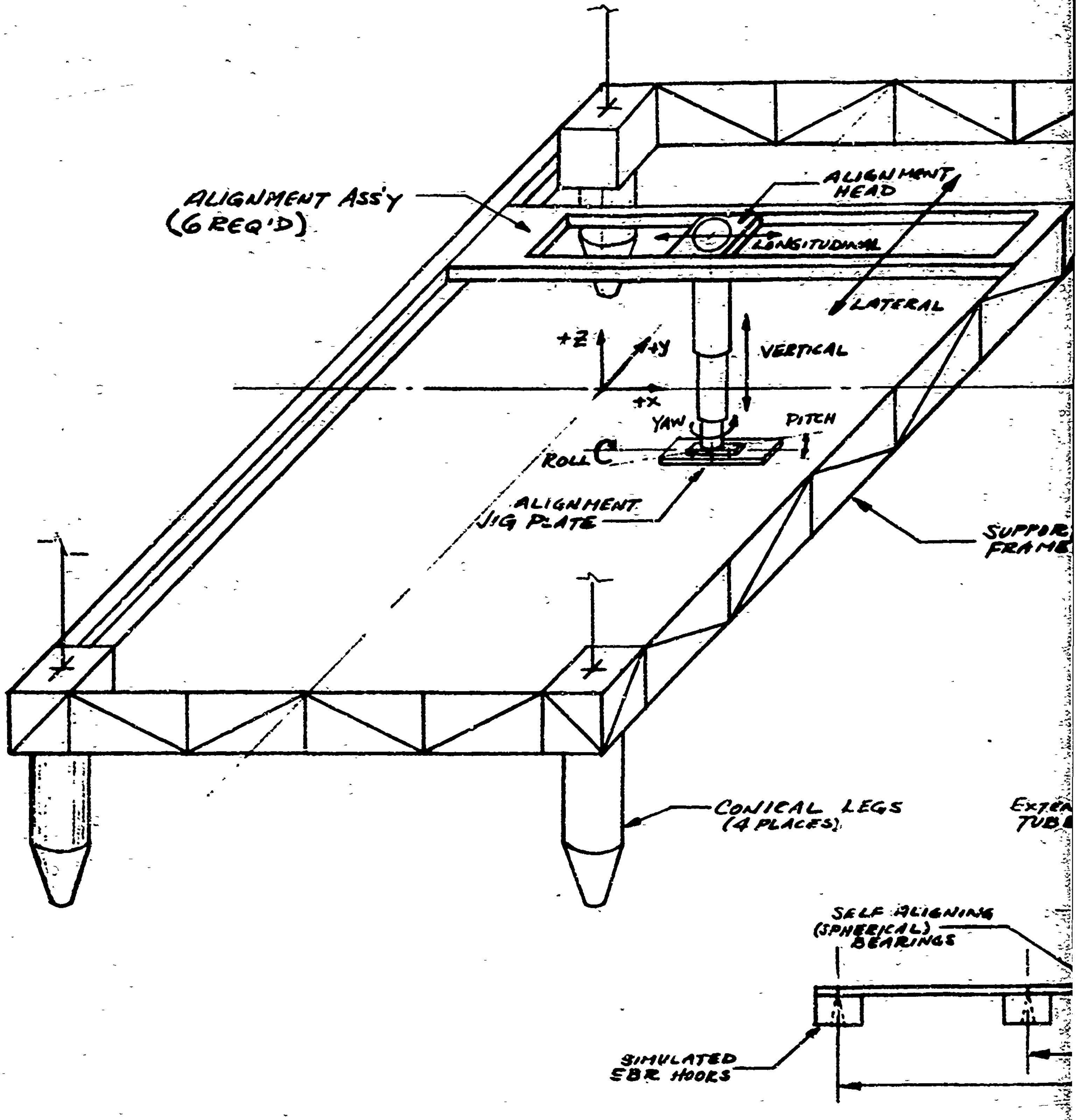


FIGURE 26, COMPUTER CONTROLLED WEAPONS ALIGNMENT JIG

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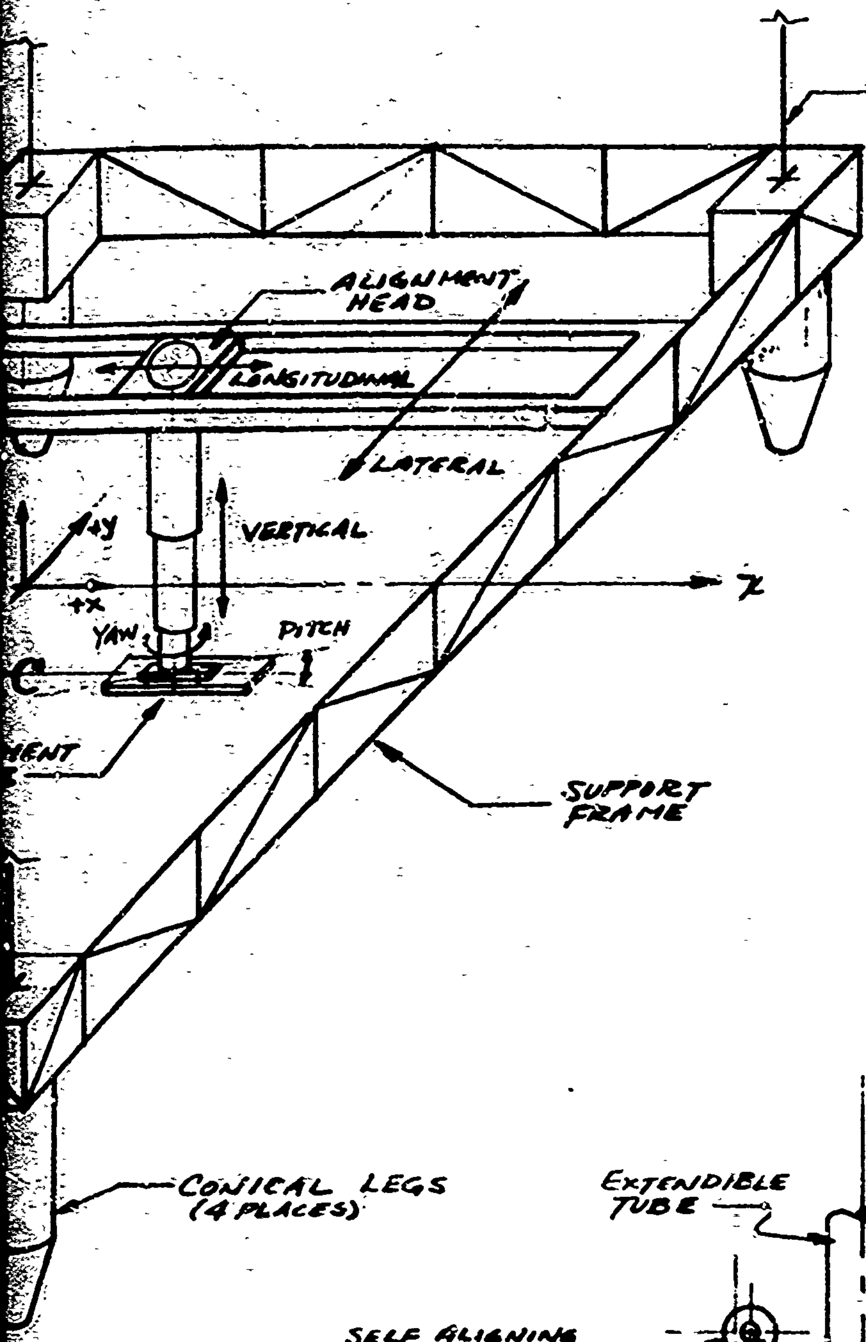

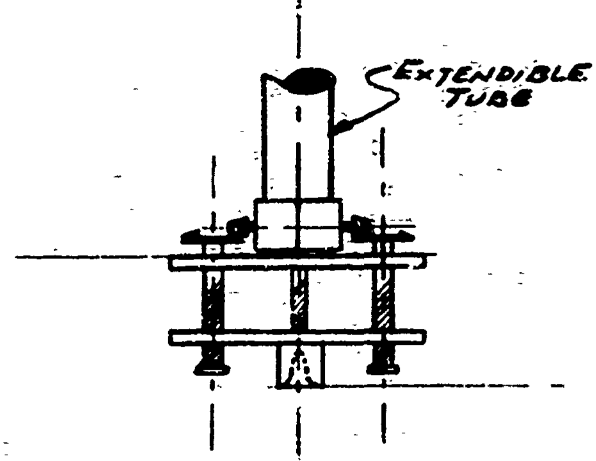

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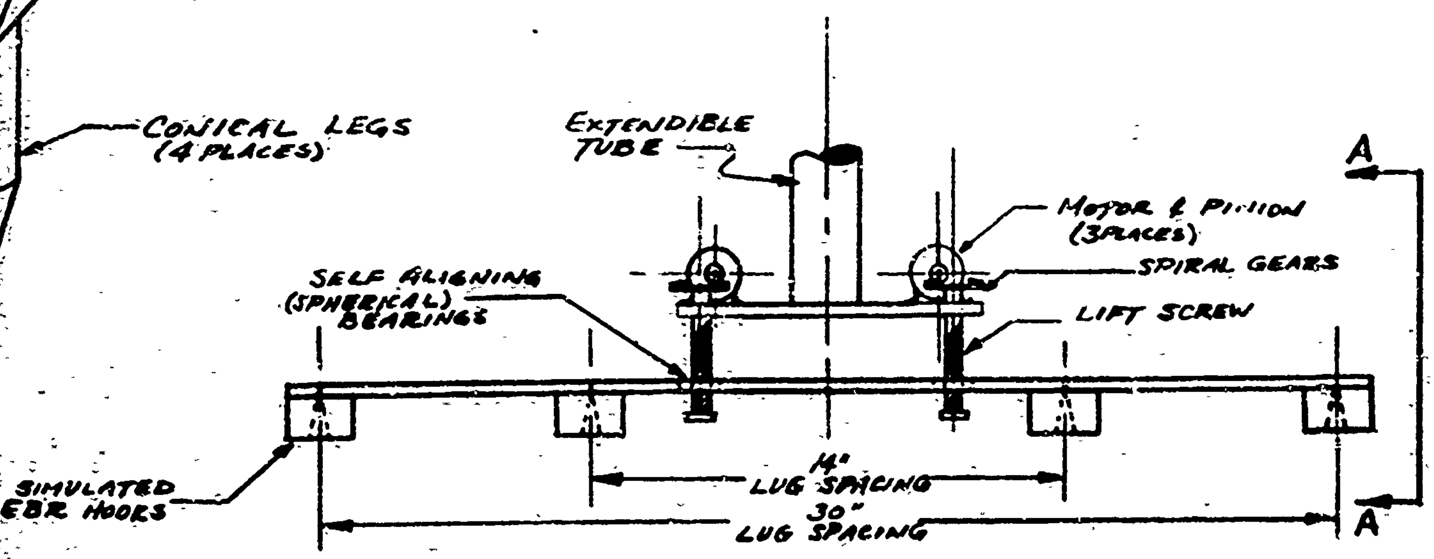


ALIGNMENT JIG PLATE DETAIL

...TROLLED
...MENT JIG

for roll and pitch angle adjustments. Yaw angle adjustments are accomplished by rotating the extendible tube in the alignment head. The alignment plate contains 4 slots corresponding to a 14-inch and 30-inch suspension hook spacing. These slots duplicate the geometry of the hook opening on the EBR and when the weapon lugs are aligned to mate with the alignment plate slots, they are properly oriented for loading onto the aircraft with no additional adjustments.

The alignment jig hardware development is well within the state-of-the-art and systems similar in operation to the alignment jig are commercially available. Development of the jig would require the adaptation of these systems to the specific requirements for weapons alignment and to the carrier environment.

d. Final Weapons Alignment

A final weapons alignment concept using a pin and cone technique has been investigated. This concept, in addition to the use of the Computer Controlled Weapons Alignment Jig, may be necessary to assure mating, due to the close tolerances between the suspension lugs and the EBR hooks.

The concept consists of an aligning pin attached to the EBR with a quick disconnect pin, such as a ball lock pin, and a conical receptacle attached to the MER, TER or single weapon. On the MER or TER, no problems are anticipated in attaching the conical receptacle. On single weapons, the receptacle will be attached to

an adjustable band or clamp which will be positioned and secured around the weapon body.

The conical receptacles will be attached to the weapons rack or store in the make-up area and the weapons aligned on the pallet with respect to the aircraft EBR hooks. In the preloading area on the flight deck, the alignment pins will be attached to the EBR's. Both the pin and cone will be designed for rapid attachment and removal by using quick connect-disconnect pins, such as ball locks. The pin and cone design will determine the maximum misalignment which can be negated, but is is anticipated that a capability of ± 2 inches in the lateral and longitudinal directions and $\pm 2^{\circ}$ pitch, yaw and roll angle will be sufficient to assure mating and latching. The forced alignment of the store lugs and EBR hooks will be made possible by an air bag attached to the bottom of the skid platform and the top of the weapons support fixture pitch platform, as shown in figure 27. The air bag provides the lift and the low friction necessary to force alignment between the pin and cone without inducing excessive loads into the EBR or the store.

The concept functions as follows: (Refer to figures 27, 28, 29)

- The conical receptacles are attached to the store or rack in the make-up area. The weapons and receptacles are aligned with respect to the aircraft EBR hooks, using the weapons pallet as a reference datum.

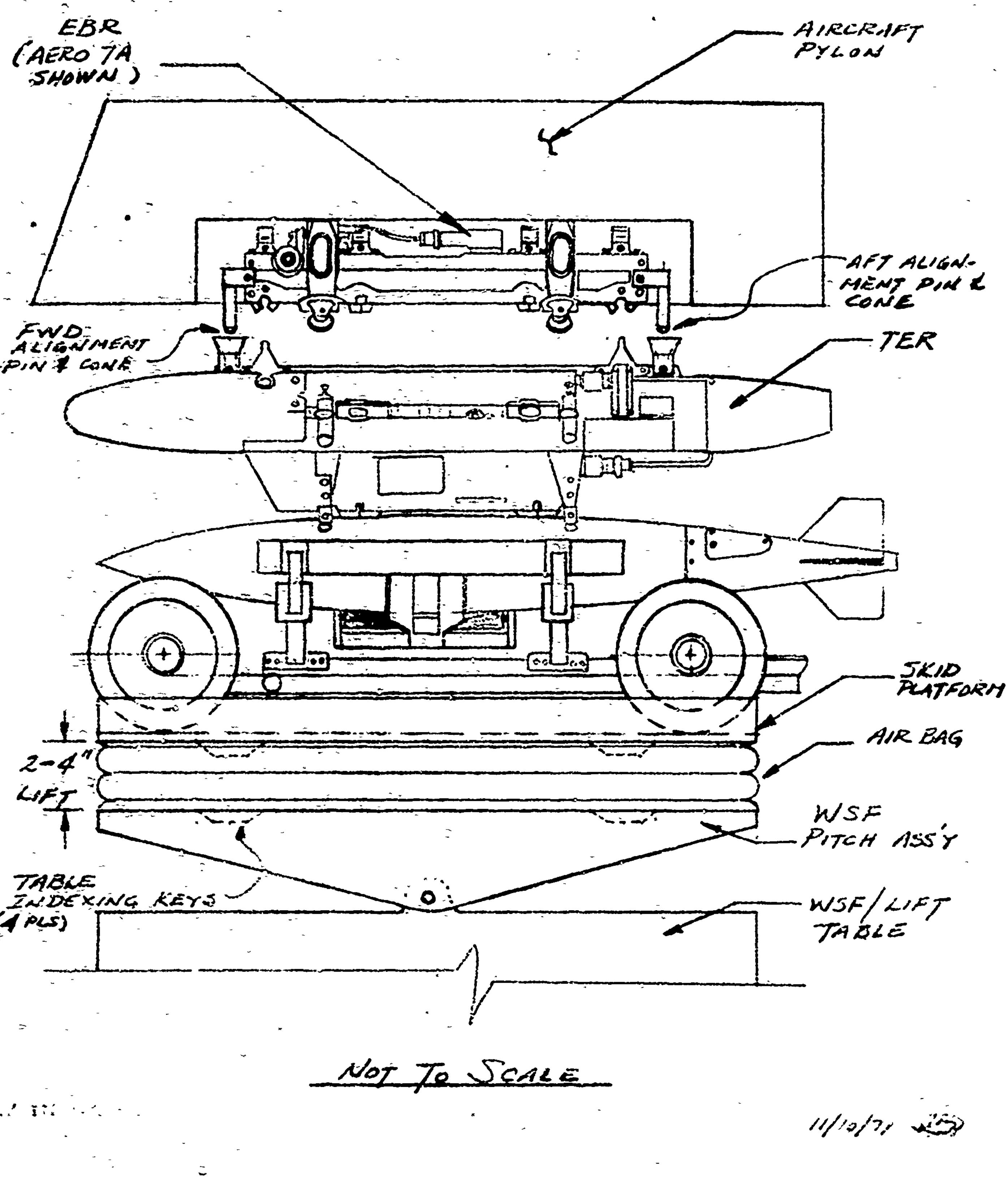


FIGURE 27. FINAL WEAPONS ALIGNMENT - PIN AND CONE CONCEPT

- The air bag is in the deflated condition and the skid platform and pitch assembly are clamped together by a solenoid operated lock.
- On the flight deck, the aircraft is prepared for loading and the alignment pins are attached to the EBR.
- The weapons pallet is moved to the rearming elevator and raised to the aircraft. When the pin and cones engage, vertical movement of the weapons pallet is halted.
- Solenoid locks holding the skid platform and WSF pitch platform together are activated and the air bag is pressurized slowly.
- As the air bag is pressurized the two platform surfaces break contact and the skid platform is free to move within the constraints of the cone and the limits of the air bag.
- As pressurization of the air bag continues, the pin and cone are smoothly mated, and the store lugs engage the EBR hooks.
- After latching has occurred, the store/skid tiedowns are released and the air bag deflated, bringing the skid platform and WSF pitch platform into contact. The two platform surfaces are guided into position by the table indexing keys and locked together.

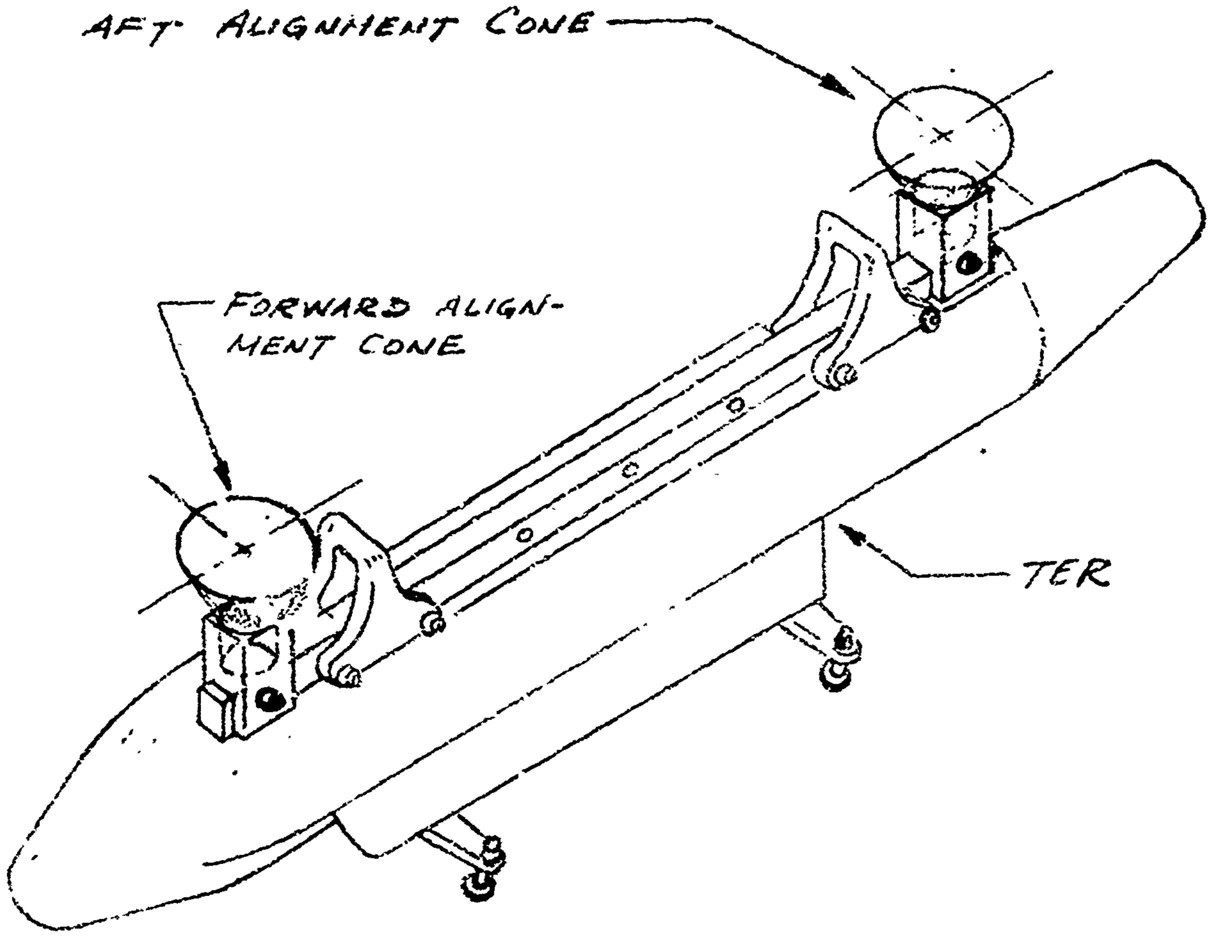
- The aircraft is moved to the post-loading area where checkout is performed, the pins and cones removed and final electrical and arming procedures are initiated.

Figure 28 illustrates the attachment of the alignment cones to a TER, and figure 29 gives the details of the alignment pin.

e. Work Platforms

To provide access to the aircraft weapon stations during weapons loading, a work platform is available for each weapons support fixture on the weapons pallet. The rail system utilized for positioning and supporting the weapon support fixtures is also used for the work platforms. The work platforms are basically personnel lifts which are mounted on the weapon support fixture rails and can be positioned forward of the weapon support fixture. The platforms can be raised and lowered by the operator stationed on the platform and provide access to a large area around the aircraft weapon station. The platforms operate independently of the weapon support fixture and can be adjusted for various heights and widths.

The weapon support fixture size determines the width of the work platform. The weapon support fixture is 30" wide and has an adjustment capability of ± 2 inches in the lateral direction. In the longitudinal direction, approximately 60 inches has been chosen for the basic work platform length. Therefore, the basic work platform is 60" x 34".



NOTE: ALIGNMENT CONES ARE ATTACHED TO TER WITH QUICK DISCONNECT PINS.

FIGURE 28. WEAPONS ALIGNMENT CONES - TYPICAL LOCATION FOR TER

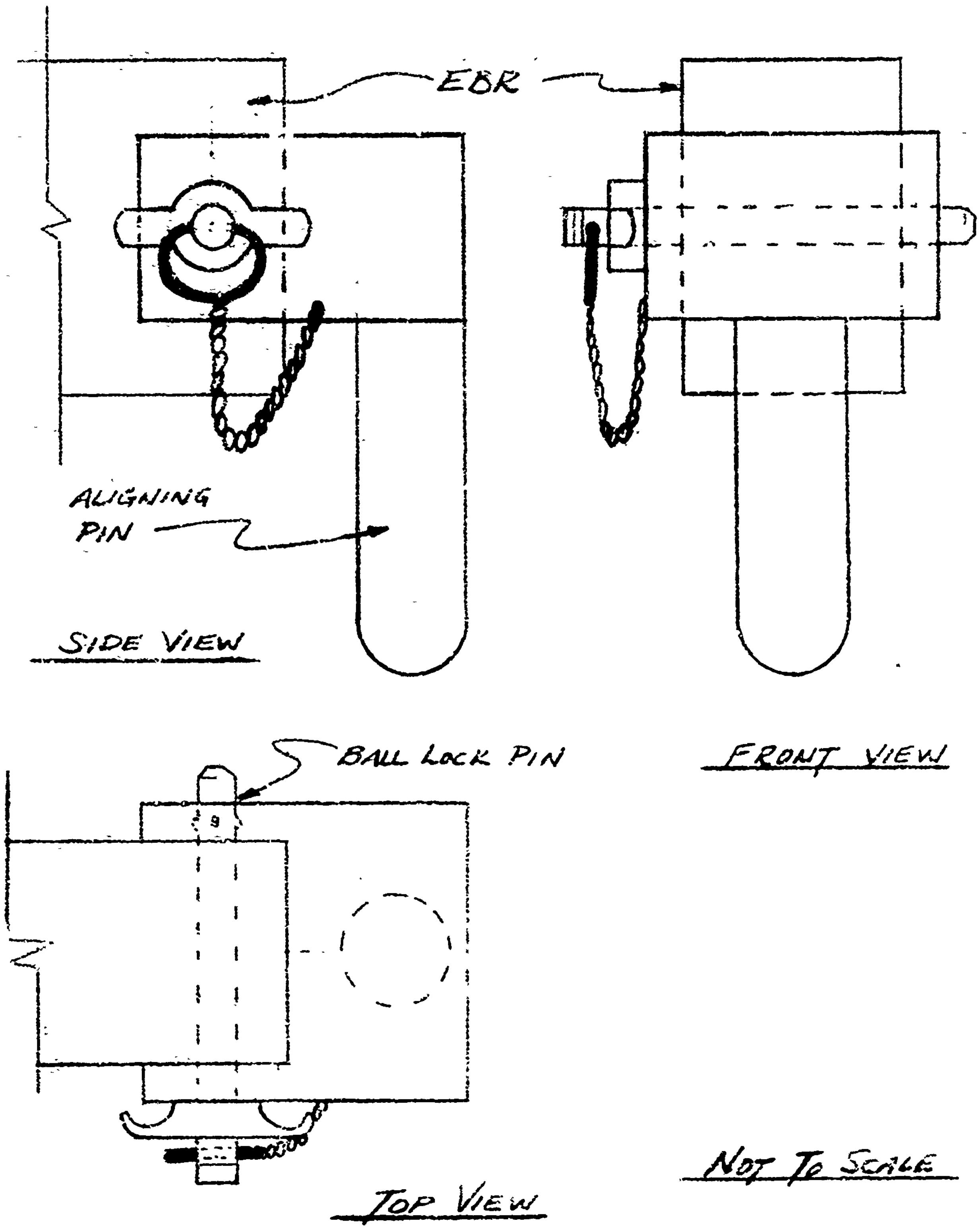


FIGURE 29. WEAPONS ALIGNMENT PIN - TYPICAL LOCATION FOR AERO-7A

In some cases, it is impossible to provide access to all areas adjacent to the weapon station. For example, the A-7 inboard and center wing stations are separated by only 36", which gives very little clearance between weapons considering that a MK 82/MER requires a width of almost 35". In these cases, the basic platform size of 34" x 60" is used. For other aircraft with greater station separations, platform extensions are used to provide a reasonable work and access space for the station. Figure 30 depicts the work platform arrangement for the A-7 aircraft. Note that the work platform for station 1 is used to provide access to the A-7 fuselage missile station by adding width extensions.

Figure 31 is a sketch of a concept for a weapon station work platform. The work platform consists of a personnel lift with an extension capability of 36". The 34" platform base height puts the top of the work platform at the same elevation as the top of the lift table on the weapons support fixture, when the work platform is in the lowered position. The platform base is mounted to the weapons pallet in the same manner as the weapons support fixture, i.e., by means of low friction ball bushings. This permits the work platforms to be moved to any position on the weapons pallet forward of the weapons support fixture. The work platforms are not connected to the weapons support fixtures and operate completely independently of the weapon support fixtures.

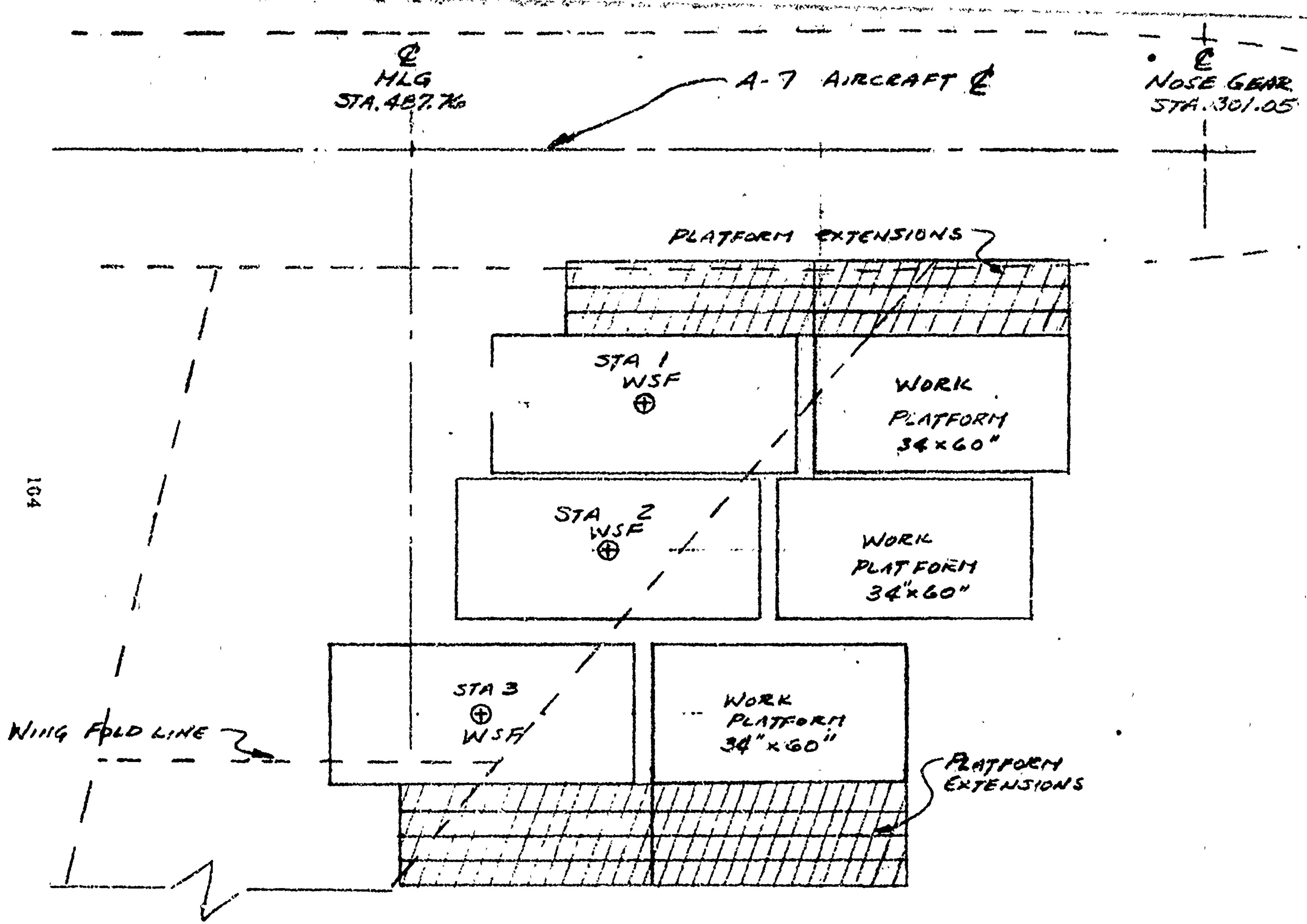


FIGURE 30. A-7 WORK PLATFORM LAYOUT

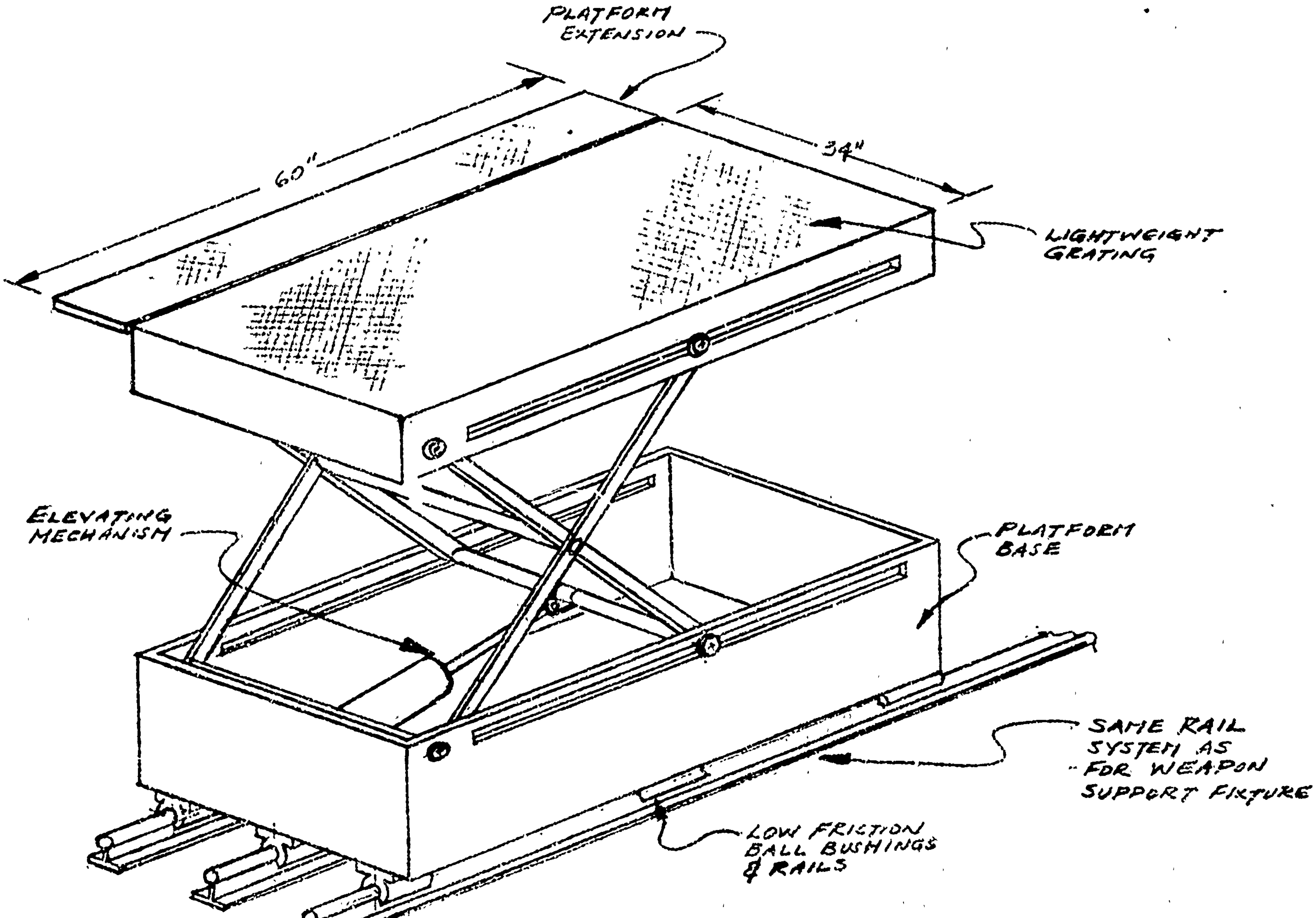


FIGURE 31. WEAPON STATION WORK PLATFORM

A remote control is provided on the work platform to allow the platform to be raised or lowered by the personnel stationed on the platform. The lateral and longitudinal movement, however, is not controlled from the platform. The platform is positioned laterally and longitudinally and locked into place prior to loading the weapons pallet on the rearming elevator.

As previously stated, the basic platform is 34" x 60". Width extensions are available to provide up to 64" x 60" platforms. In addition, length extensions may be added to provide access between weapon stations where space is available. The platform and extensions are made from lightweight grating and the extensions can be braced for rigidity.

In the overall sequence of operations for the rearming station, the work platform preparation will take place at the same time the weapons are being placed on the weapon support fixtures at the make-up area. After weapons alignment, either manually or by using the alignment jig, the platforms are moved up to the weapons support fixture and locked into place. The weapons pallet is transferred to the rearming elevator, weapons loading personnel man the work platform, and the weapons pallet is raised to the aircraft. At this point, the work platforms can be raised or lowered as necessary to provide visual observations of loading and to provide access to the manual controls on the weapons support fixture.

In addition of providing access to the aircraft stations during loading, the work platforms could be used for servicing and maintaining the aircraft and the rearming station support equipment, such as the nose gear bridge and main gear support pads.

Work platforms providing the platform dimensions, lift heights, and weight capacities required for this application are presently available. Some redesign will be required to provide a rail mounting and to meet the standards required by the aircraft carrier environment.

f. Weapon Support Fixture

The weapon support fixture supports and secures the ordnance from ordnance pallet make-up through weapons loading and provides necessary movement of the ordnance for final alignment to the aircraft.

The weapons support fixture is mounted on top of a lift table which in turn is structurally supported by the weapons pallet. The lift table and weapon support fixture form a movable platform which can be positioned laterally, $\pm Y$, and longitudinally, $\pm X$, on the weapon pallet. The lift table provides the necessary positioning of the ordnance in the $\pm Z$ direction.

The movable platforms are moved aft, -X, on the ordnance pallet until the weapon support fixtures interfaces with the make-up/ holding ramp (see figure 2). The loaded skids are moved on and

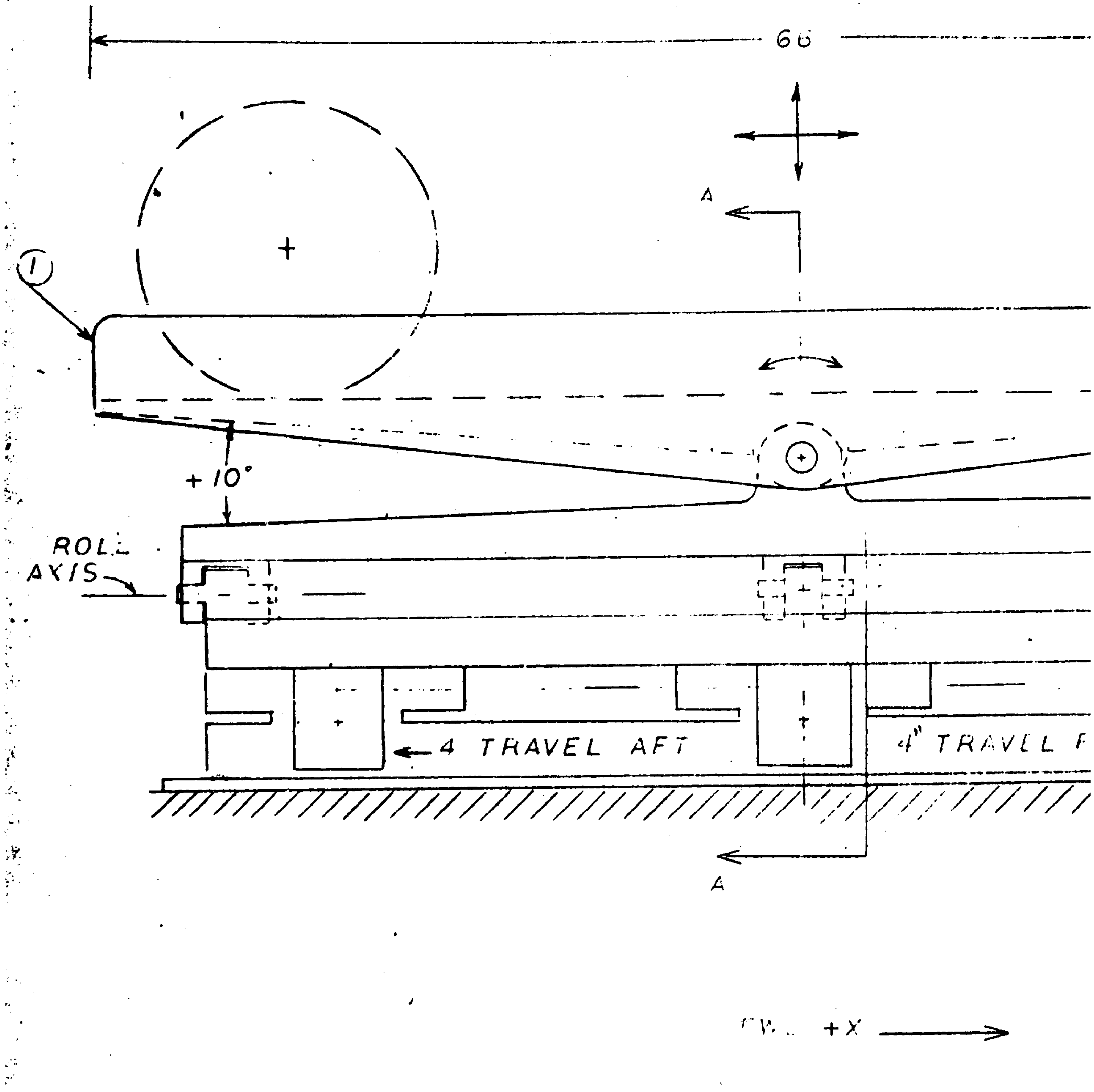
secured to the weapon support fixture. The weapons pallet moves to a fixed position under an ordnance alignment fixture which has indexing probes corresponding to the bomb rack pattern of the aircraft to be loaded.

The movable platforms are positioned on the fixed ordnance pallet in the X and Y directions until ordnance support hooks match the ordnance alignment fixture pattern. The weapon support fixture then is adjusted in yaw, pitch, and roll as necessary to correspond to the aircraft to be loaded. The lift table is raised until the ordnance support hooks match the alignment fixture in Z-direction, and any required fine adjustments are also made. The movable platforms are then locked onto the ordnance pallet.

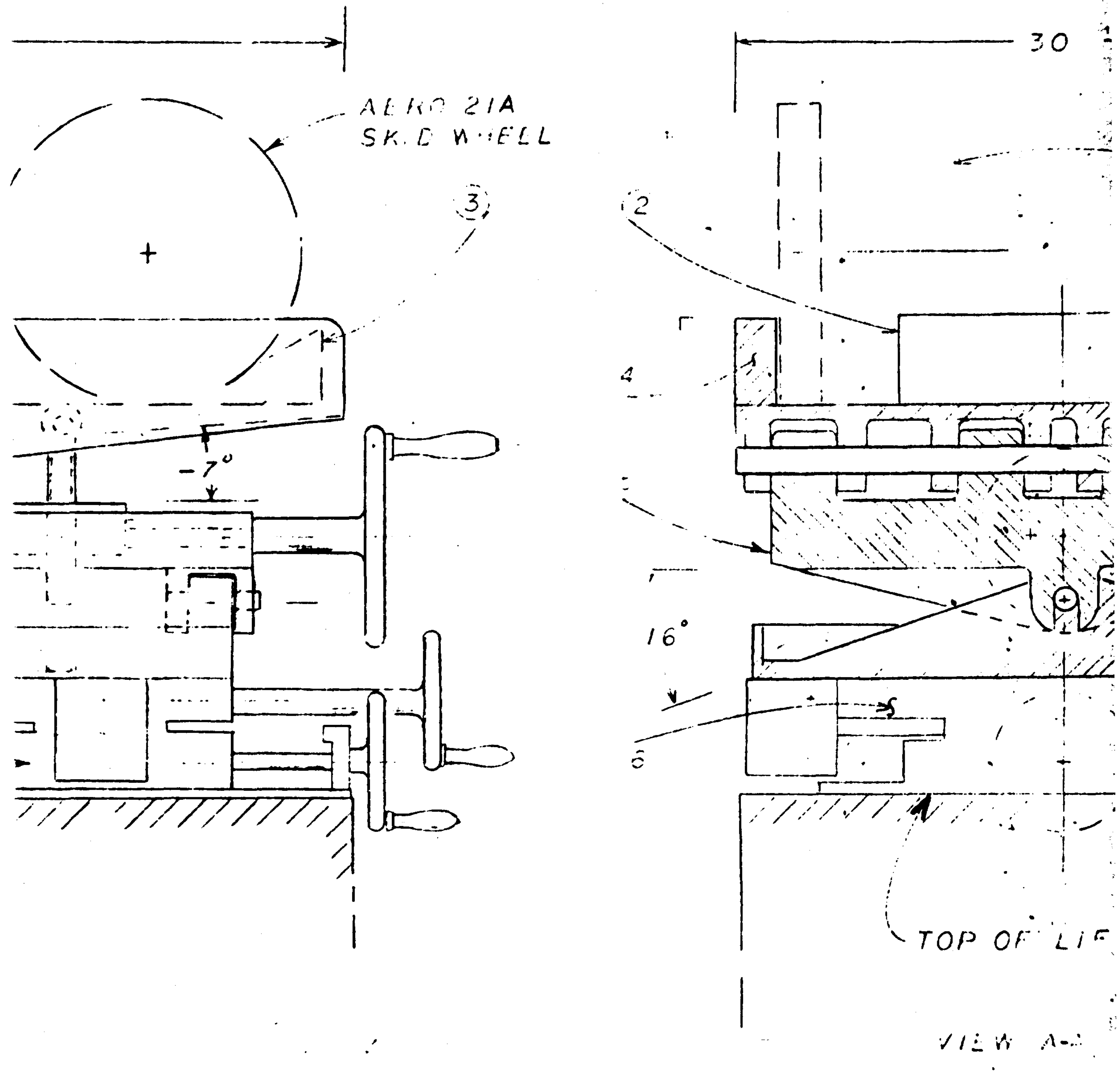
The loaded and aligned weapons pallet moves into a fixed position on the elevator and is raised under a prepositioned aircraft. The weapon support fixtures moves the ordnance to make any necessary final adjustments in yaw, pitch, roll or $\pm X$, $\pm Y$ directions. The lift tables independently move the ordnance upward the final two or three inches until the bomb rack hooks and ordnance lugs lock.

Since the weapons support fixture is considered to be a pacing hardware development item, the design concept was investigated in more depth than the other rearming station subsystems.

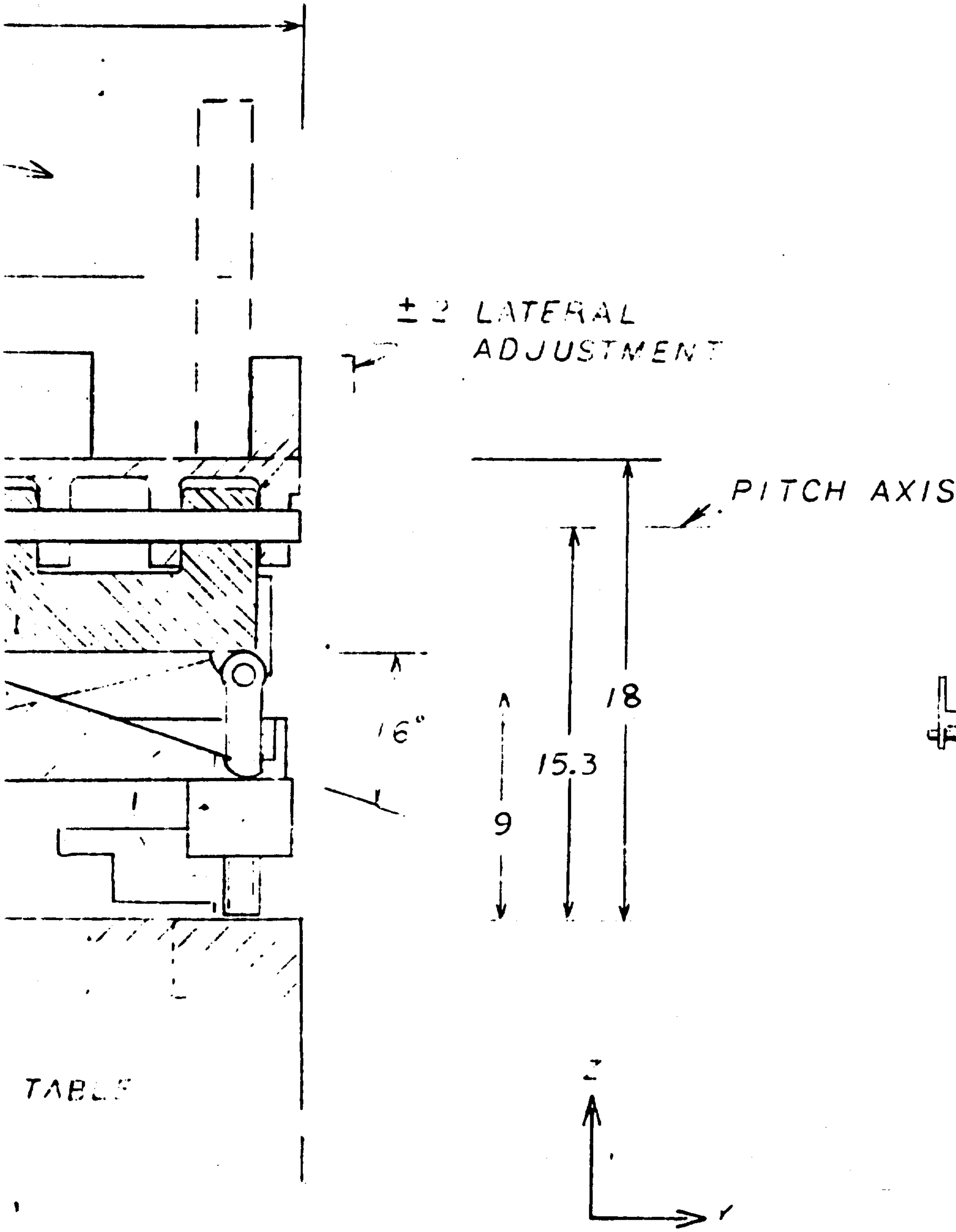
A hardware concept for meeting requirements specified for the weapons support fixture in Data Sheet No. 400 is defined below. Refer to figures 32 and 33.



A


30
AERO 21A
SK.D WHEEL
3
2
4
-7°
16°
6
TOP OF LIF
VIEW A-

FIND NO	
1	PIT
2	SKI
3	SKI
4	WH
5	RO
6	LA
	YAW



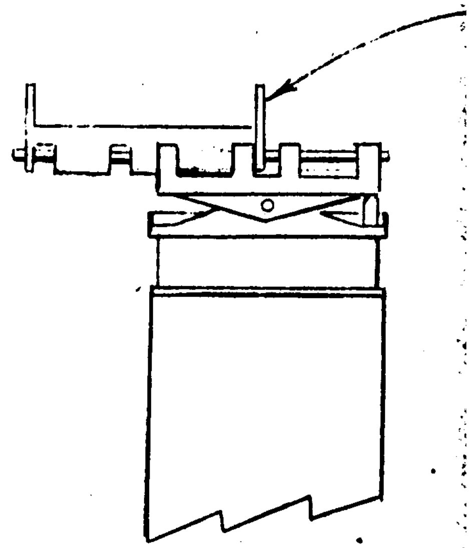
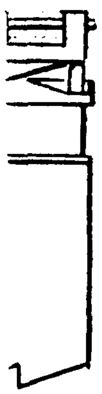


FIGURE 32 — WEAPON

LIST OF MAJOR COMPONENTS

D	ITEMS	
	PITCH PLATFORM	
	SKID TIEDOWN ASSEMBLY	
	SKID POSITION CHOCKS	
	WHEEL GUIDE ASSEMBLY	
	ROLL ASSEMBLY	
	LATERAL / LONGITUDINAL &	SEE DWG
	YAW ASSY	NO 400



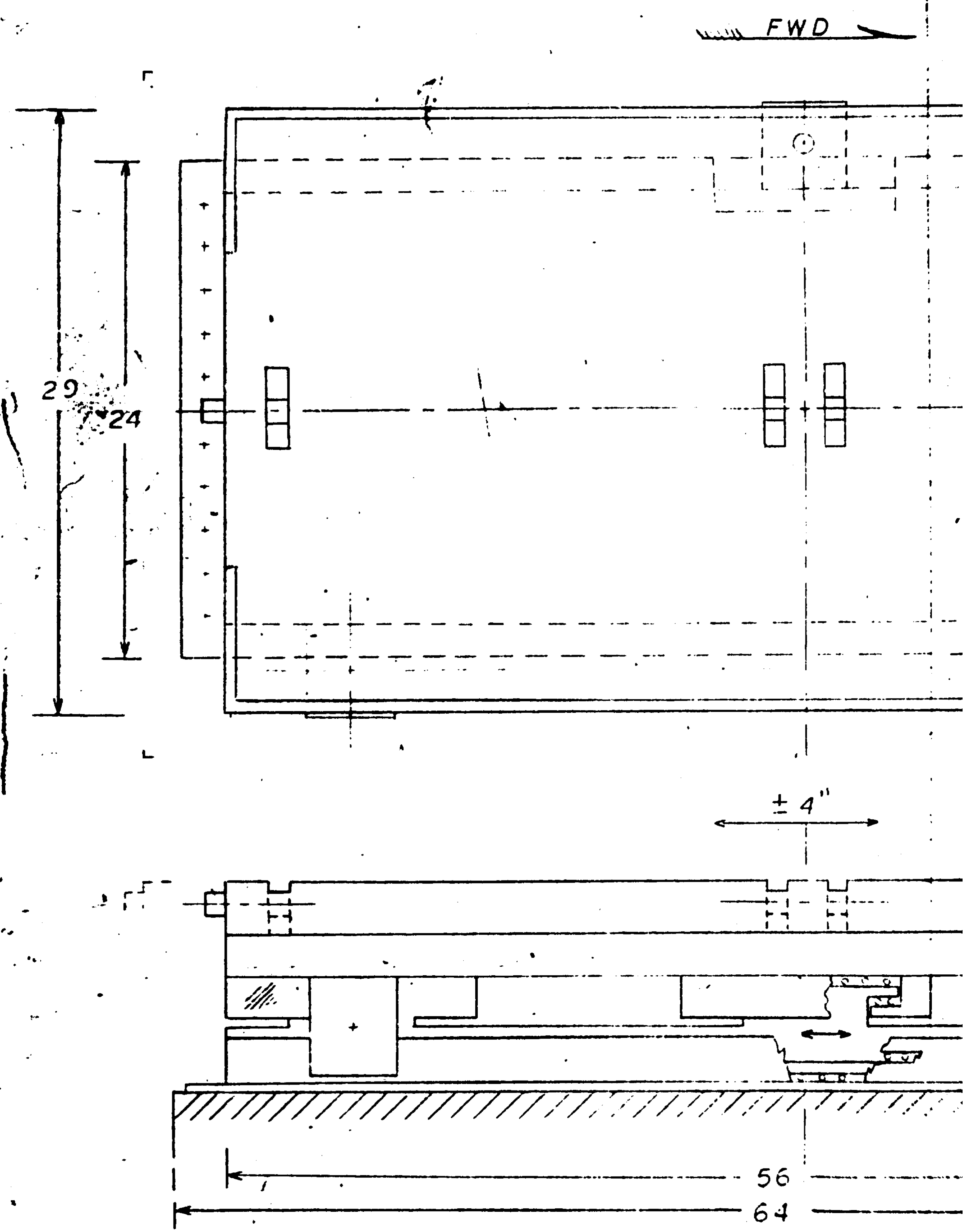
PITCH PLATFORM
OFF-SET TO LEFT FOR
LOADING A-7 INBOARD
WING STATION

SCALE 1:6

0 6 12

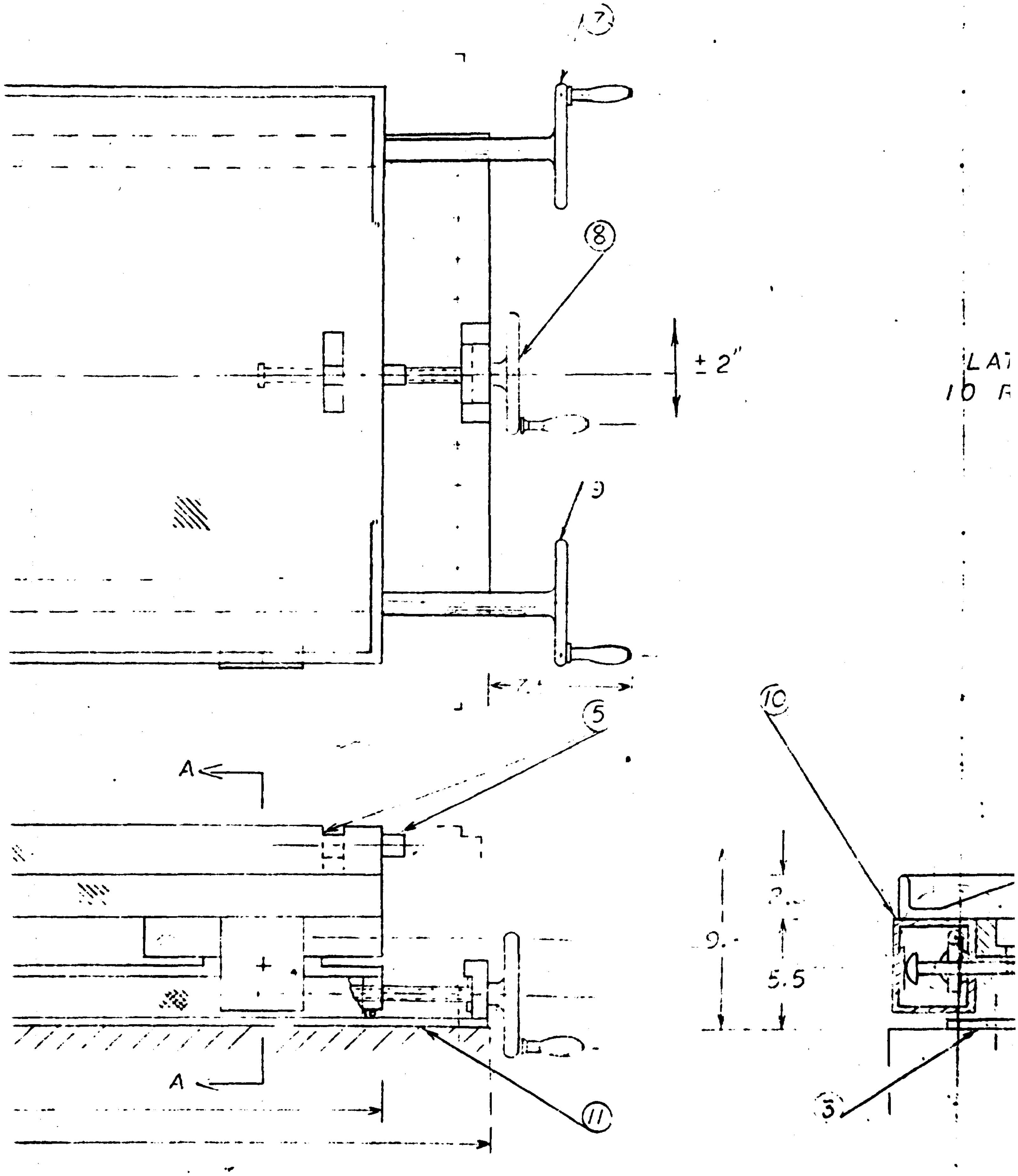
EAPON SUPPORT FIXTURE (400) 11/5/71 109

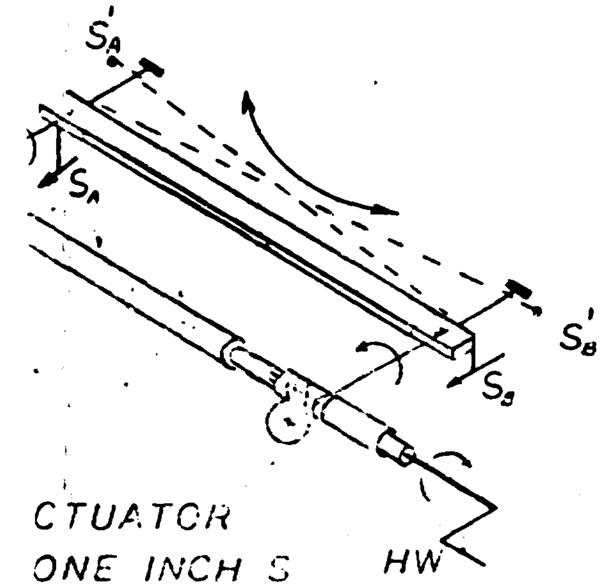
D



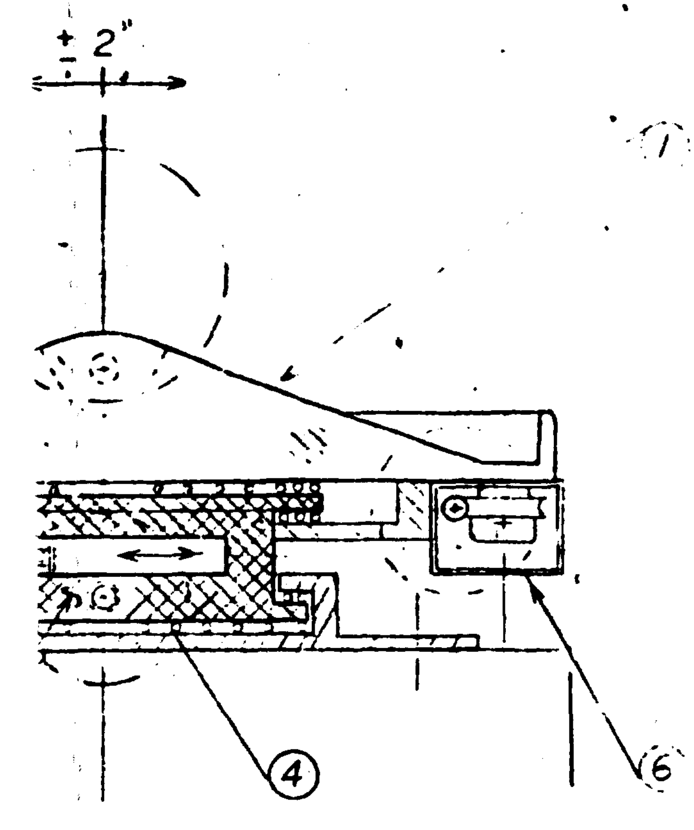
FWD
29
24
± 4"
56
64

B





CTUATOR
ONE INCH S
MOVEMENT



EW A–A

LIST OF MAJOR CO

FIND NO	ITEM
1	A FRAME LATE
2	CENTRAL SLIDIN
3	BASE PLATE, LC
4	BALL BEARING
5	PIN MOUNTS F
6	ROLL ACTUATO
7	ROLL ACTUATC
8	LONGITUDINAL
9	LATERAL ACTU
10	LATERAL ACTU
11	TOP OF LIFT

*NOTE:

± 2.5 DEGREE YAW CAPABIL
ACTUATOR DRIVE GEAR A
GEAR & VICE VERSA

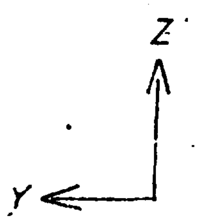


FIGURE 33– LATERAL/LONGITU
OF WEAPONS SUPPOR

D

MAJOR COMPONENTS

ITEM
AME LATERAL STRUCTURE
RAL SLIDING BEAM
PLATE, LONG. ASSY
BEARING UNITS
IOUNTS FOR ROLL ASSY
ACTUATOR GEAR BOX
ACTUATOR HANDWHEEL
ITUDINAL ACTUATOR HANDWHEEL
RAL ACTUATOR HANDWHEEL*
RAL ACTUATOR GEAR BOX*
OF LIFT TABLE

W CAPABILITY OBTAINED BY DISENGAGING AFT LATERAL VE GEAR AND ROTATING FWD. LATERAL ACTUATOR DRIVE /ERSA

SCALE 1:6

0 6 12 INCHES

/LONGITUDINAL ASSEMBLY 10/13/71

NS SUPPORT FIXTURE (460)

- **Skid/Weapon Loading**

A loaded AERO 21A skid or the A/M 32 K-5(V) Munitions Handling Set (presently being developed) is rolled from a holding ramp (in the ordnance pallet make-up area) onto the pitch platform of the weapon support fixture.

Manual force for moving the weapons skid onto the pitch platform is assumed for the baseline system. Advanced versions will utilize automated conveyors or driverless skids controlled by the weapons strike-up officer.

- **Skid Positioning**

The weapons skid is guided onto the pitch platform by two wheel guide assemblies mounted on the pitch platform. Spring loaded-vertical wheel guides keep the weapons skid on center as it rolls into the forward position.

- **Skid Tie-Down Assembly**

The skid tie-down assembly secures and restrains the weapons skid on the weapons support fixture from skid/weapons loading until the empty skid is returned to the make-up area.

The baseline system accomplishes tie-down by using a shock mounted, self-locking, lug mechanism which engages a vertical pin component mounted on the front axle of the weapons skid. This mechanism secures the front axle in the X, Y and Z direction. A "lug release" cam is actuated to unlock the lugs

before the empty skid is moved from the weapon support fixture. This type mechanism is simple, reliable and is used extensively in military and commercial hardware.

The positioning chocks forward of the skid front wheels and brakes on the weapon skid may be used as back-up securing capability, if necessary.

- <u>Pitch Platform</u>

The pitch platform structurally supports the weapons skid and provides a 10° nose up and 7° nose down pitch adjustment capability. See figures 32 and 33 for general configuration. The pitch platform houses the skid positioning assembly and skid tie-down assembly and is mounted on the roll assembly.

Pitch adjustments are made by rotation of a handwheel at the forward end of the weapon support fixture. The handwheel drives a rotating lock nut which moves a jack screw up and down thereby tilting the pitch table. This type of high strength screw actuator is available commercially and has a history of reliable use in milling machines and other machine tools. Approximately 15 seconds is required to move a loaded pitch platform 7 degrees.

- <u>Yaw Assembly</u>

The yaw assembly provides a yaw angle adjustment of $\pm 2\ 1/2^{\circ}$. The yaw adjustment is obtained by engaging and driving either the forward or aft lateral screw jack while holding the

other lateral drive stationary, or by driving the fore and aft screws in opposite directions.

- Roll Assembly

The roll assembly provides the capability of adjusting the skid/weapon roll angle ± 7 degrees minimum. The assembly is mounted under the pitch platform and uses a similar jack screw and handwheel adjustment mechanism.

Various types of easy to read indexes are commercially available for visual display of the roll and pitch angles.

Approximately 15 seconds is required to move a loaded roll assembly 7 degrees with the jack screw and handwheel mechanism.

- Lateral/Longitudinal Adjustment Assembly

The bottom portion of the weapon support system provides for positive positioning of ± 4 inches longitudinally, ($\pm$X), and ± 2 inches laterally ($\pm$Y).

This assembly uses small low friction parallel bearing assemblies to support the sliding members. Jack screw and handwheel mechanisms are used for positive positioning and control.

The baseline weapon support fixture utilizes handwheels for all pitch, yaw, roll, lateral and longitudinal movements; however, these actuators may easily be converted to motor driven

and remote control units. Little structural change would be necessary to incorporate a numerically controlled positioning/ alignment system at a later date.

6. Projected Performance of Rearming Station

A detailed operational analysis of the two pass rearming station based upon the hardware data generated is contained in Section V-E of this report. Actually a baseline operational sequence of events chart was constructed at the beginning of the study. The chart was used during this study to pinpoint pr 'ems, investigate alternative subsystem concepts for resolving problems, and to help in the selection of hardware concepts. Results of the latest projected performance of the two pass "baseline" rearming station are outlined below.

The two make-up areas outside the rearming station elevator allows simultaneous make-up and alignment operations to be accomplished independent of the elevator position. These specialized make-up areas provide adequate thermal control, lighting and special facilities not available on the rearming station elevator. By maintaining parallel operations in the bi-level make-up areas the below deck operations are balanced well with the above deck operations. That is, a minimum of equipment idle time exists. The "baseline" concept provides operational flexibility, redundancy and rapid aircraft loading for CVA strike missions.

Analysis results indicates that the "baseline" rearming station can accomplish ordnance loading on an average of one aircraft each 3.5 minutes. The average time between loading can be expected to be between 3 and 4 minutes for the various type aircraft and ordnance loads.

The baseline rearming station is operated by 39 personnel, 14 below deck and 25 on the flight deck. The below deck station personnel are composed of two crews of seven each. The flight deck crews are: 4 tow truck drivers, 4 assistances and 8 wing walkers, (16 personnel); 4 preloading specialists, one loading officer and 4 post loading specialists.

E. OPERATIONAL ANALYSIS

1. Introduction

This section defines the operational sequence, time and manpower required for a baseline rearming station. Critical operations below and on the flight deck are identified and areas for further optimization are outlined.

2. Definition of Below Flight Deck Operations

a. Objective

The purposes of this section and associated analyses are to:

- Define a baseline sequence of operations for below flight deck activity supporting a unit load rearming station
- Define necessary manpower and work teams for ordnance pallet make-up and alignment

- Outline skid/weapons flow from the main deck to the make-up areas

b. Loading Requirements

In order to establish a baseline sequence the following "worst case" loading requirements were established:

(1) Seven A-7 aircraft are to be loaded with weapons in 30 minutes with a rearming station in the ready status

(2) Weapons Load: 18,300 lbs/A-C

Station 1 & 8	6 MK 82 on MER
2 & 7	6 MK 82 on MER
3 & 4	4 MK 82 on MER

The MK82 weapons mounted on MER's are transported from the magazine to the rearming station by AERO 21A skid or A/M 32 K-5(V) Munition Handling Sets. All seven A-7 aircraft are assumed to be loaded sequentially from one weapons rearming station, also the A-7 aircraft are assumed to be fueled and spotted on the flight deck with tow bar attached. Preloading preparations, weapons loading and post loading preparations are accomplished in sequence. Loaded aircraft are respotted on flight deck prior to launch.

c. Rearming Station Layout

The rearming station layout used for this operations analysis is the two-pass "baseline" rearming station shown in figure 2. The rearming station is assumed to be located forward of aircraft

elevator number 1 on aircraft carrier CVA(N) 65 for this analysis. Reference 15 was used for carrier configuration data.

The station contains two areas for ordnance pallet make-up and alignment; one area at the 03 level and one area at the 01 + level Ordnance flow from the main deck to these make-up areas via elevators A and B. Weapons mounted on bomb skids are moved from the weapons elevator to a holding ramp and onto weapon support fixtures located on the ordnance pallet. The weapons/skids are secured to the weapon support fixtures and aligned. The loaded and aligned ordnance pallet is then moved onto the rearming station elevator and raised to flight deck level for weapons loading.

Weapons flow from magazine and assembly areas (located at the hold level, second platform level, and first platform level) to the weapons rearming station (see figure 34). The forward lower stage (LS) elevators number 1, 2, 3 and 4 shuttle weapons/skids from hold and second platform to the second deck level. The forward upper stage (US) elevators number 11, 12 and 13 move the weapons/skids to the main deck level where they are loaded onto weapons elevators A or B which feeds the rearming station.

Aft LS elevators number 5, 6 and 7 shuttle the ordnance from hold, the first platform and second platform levels to the second deck level. There the ordnance/skids are transferred to US elevators number 14 and 15 for strike up to the main deck. On the main deck

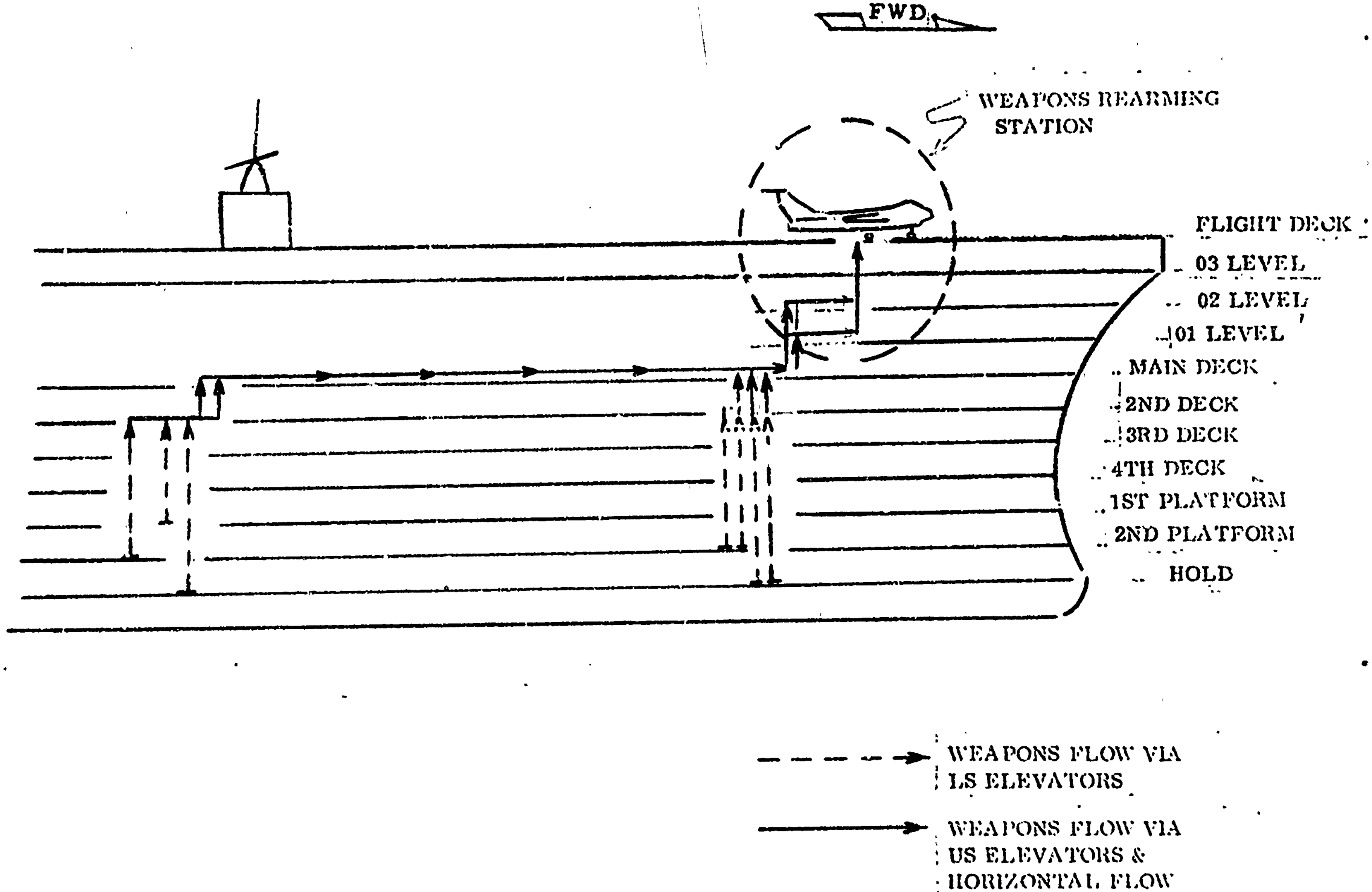


FIGURE 34. GENERAL WEAPONS/SKIDS FLOW TO WEAPONS STATION

the ordnance/skids move along conventional routes to weapons elevators A and B below the rearming station.

d. Manpower

Analysis shows that the following work teams are required for manning the two make-up and alignment areas.

Table 5. Baseline Rearming Station, Below Flight Deck Manpower Requirement

Operation	Crew No.	Manpower
(1) MAKE-UP AREA NO. 1 - Load weapons/skids on the ordnance pallet, align the weapon lugs, secure the ordnance pallet on the elevator, accomplish final alignment and weapon movement for ordnance loading, return to make-up area with the ordnance pallet.	1	6 Ordnance Handling and Alignment Specialists 1 Make-up Area Coordinator and Controller
(2) MAKE-UP AREA NO. 2 - Same type duties as Crew Number 1	2	6 Ordnance Handling and Alignment Specialists 1 Make-Up Area Coordinator and Controller
Rearming Personnel Below Flight Deck		14

e. Sequence of Operation

(1) Introduction

Analysis results indicate that for a small to medium size strike mission one weapons rearming station can complete

loading one aircraft each 3.5 minutes average. This 3.5 minutes is the time between successive "loading completions" after the rearming station start up process is completed.

Aircraft movements on the flight deck are synchronized with the ordnance movements as they flow through the weapons rearming station. Flow processes and activity on the flight deck are documented in Section V-E.3. Summarized, these activities are as follows:

(a) A preconfigured aircraft, on the flight deck, is moved to a preloading station, preloading preparation is accomplished, the aircraft is moved into the loading station, positioned and secured, ordnance is loaded. The empty ordnance pallet is recycled. The loaded aircraft is unlatched and moved out of the loading station. Post loading preparations are made on the aircraft and the aircraft is positioned for launch.

(b) Analysis results indicate that <u>2.5 minutes</u> are required to load the weapons and move the aircraft out of the station after preloading preparation and movement of the aircraft into the rearming station are completed.

(2) Make-Up Areas Operational Requirements

Figure 35 outlines the general sequential requirements for below flight deck operations. Analyses indicate that four and one-fourth minutes are required to make-up, align and move an ordnance pallet on the rearming elevator. Raising the ordnance pallet, loading the weapons and lowering the ordnance pallet require two and one-half minutes. Simultaneous operations are accomplished in make-up area number 1 and number 2 thereby adding a high degree of redundancy and reliability.

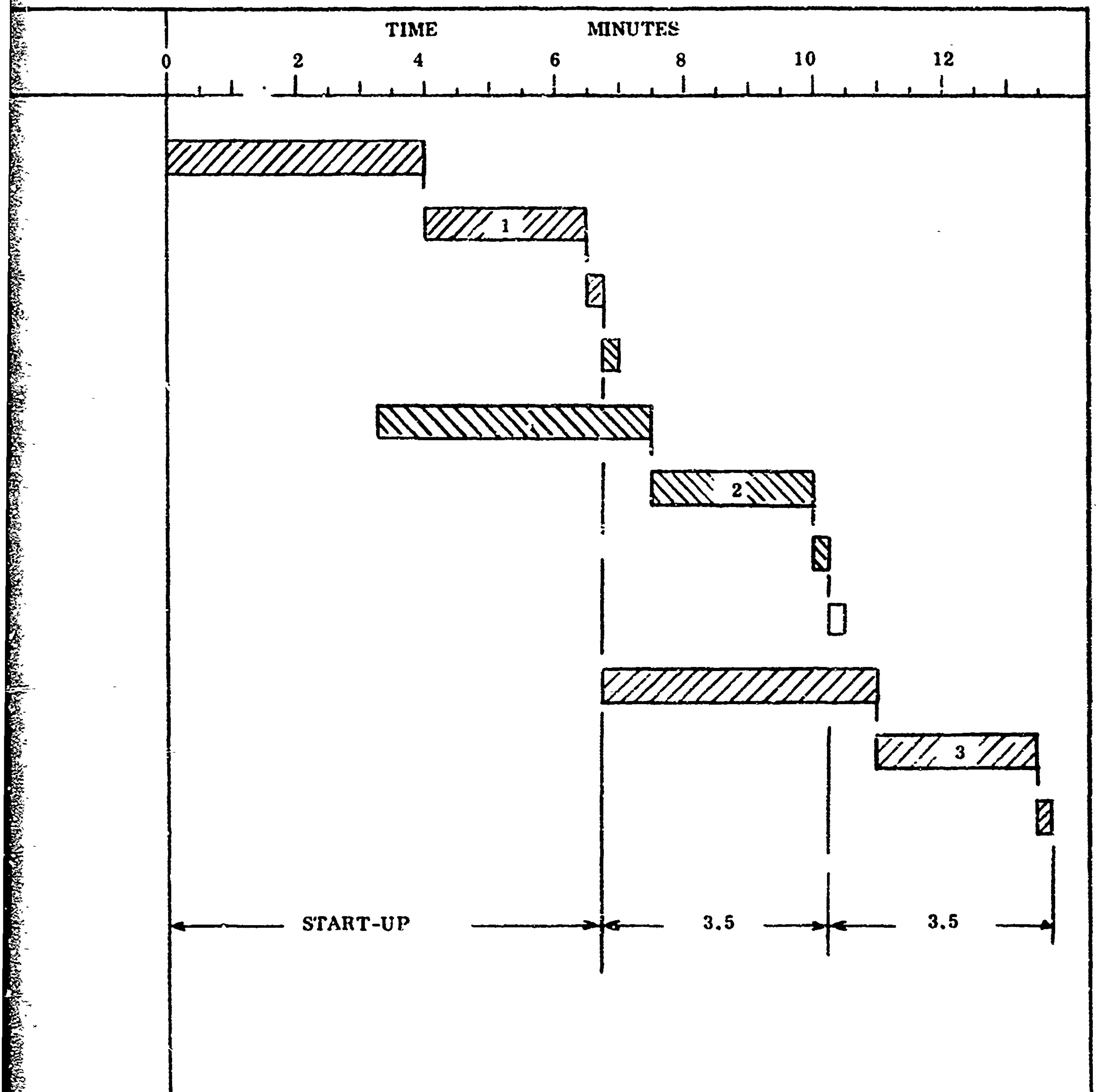
Figure 36 illustrates the sequential requirements from a weapons strike-up viewpoint. The hardware flow for meeting these requirements are outlined below.

(3) Operational Sequence

Various operational sequence and make-up area configurations were investigated. One, two and three ordnance elevators feeding the make-up areas were analyzed. One elevator, even an oversized 20 foot by 20 foot elevator, feeding the two make-up areas resulted in loading delays and limited operational flexibility. Three ordnance-feed elevators reduces the elevator cycle time and adds operational capability; however, the third elevator adds little capability to a two feed-elevator concept. The two feed elevator concept was selected and used in defining the baseline operational sequence.

SEQ NO.	GENERAL SEQUENCE BELOW FLIGHT DECK LEVEL	0 2
1	MAKE-UP, ALIGN & MOVE ORD. PALLET #1,(OP_1)ON ELEVATOR	
2	RAISE OP_1, LOAD WEAPONS & LOWER OP_1	
3	UNLOCK OP_1 FROM ELEV. & MOVE TO MAKE-UP AREA #1	
4	RAISE EMPTY ELEVATOR - 1 FLOOR	
5	MAKE-UP, ALIGN & MOVE OP_2 ON ELEVATOR	
6	RAISE OP_2, LOAD WEAPONS & LOWER OP_2	
7	UNLOCK OP_2 FROM ELEV. & MOVE TO MAKE-UP AREA #2	
8	LOWER EMPTY ELEVATOR - 1 FLOOR	
9	MAKE-UP, ALIGN & MOVE OP_1 ON ELEVATOR	
10	RAISE OP_1, LOAD WEAPONS & LOWER OP_1	
11	UNLOCK OP_1 FROM ELEVATOR & MOVE TO MAKE UP AREA #1	
	• • •	← STA

FIGURE 35. TIME SEQUENCE CHART - REARMING STATION WITH BI-LEVE



RMING STATION WITH BI-LEVEL MAKE-UP AREAS

B

SEQ NO.	GENERAL SEQUENCE BELOW FLIGHT DECK LEVEL
12	RAISE EMPTY ELEVATOR - 1 FLOOR
13	MAKE-UP, ALIGN & MOVE OP_2 & MOVE ONTO ELEVATOR
14	RAISE OP_2, LOAD WEAPONS & LOWER OP_2
15	UNLOCK OP_2 FROM ELEVATOR & MOVE TO MAKE-UP AREA #2
16	LOWER EMPTY ELEVATOR - 1 FLOOR
17	MAKE-UP, ALIGN & MOVE OP_1 ONTO ELEVATOR
18	RAISE OP_1, LOAD WEAPONS & LOWER OP_1
19	UNLOCK OP_1 FROM ELEVATOR & MOVE TO MAKE-UP AREA #1
20	RAISE EMPTY ELEVATOR - 1 FLOOR
21	MAKE-UP, ALIGN & MOVE OP_2 ONTO ELEVATOR
22	RAISE OP_2, LOAD WEAPONS, LOWER OP_2
23	UNLOCK OP_2 FROM ELEVATOR & MOVE TO MAKE UP AREA #2
24	LOWER EMPTY ELEVATOR - 1 FLOOR
25	MAKE-UP, ALIGN & MOVE OP_1 ONTO ELEVATOR
26	RAISE OP_1, LOAD WEAPONS, LOWER OP_1
27	UNLOCK OP_1 FROM ELEVATOR & MOVE TO MAKE-UP AREA #1

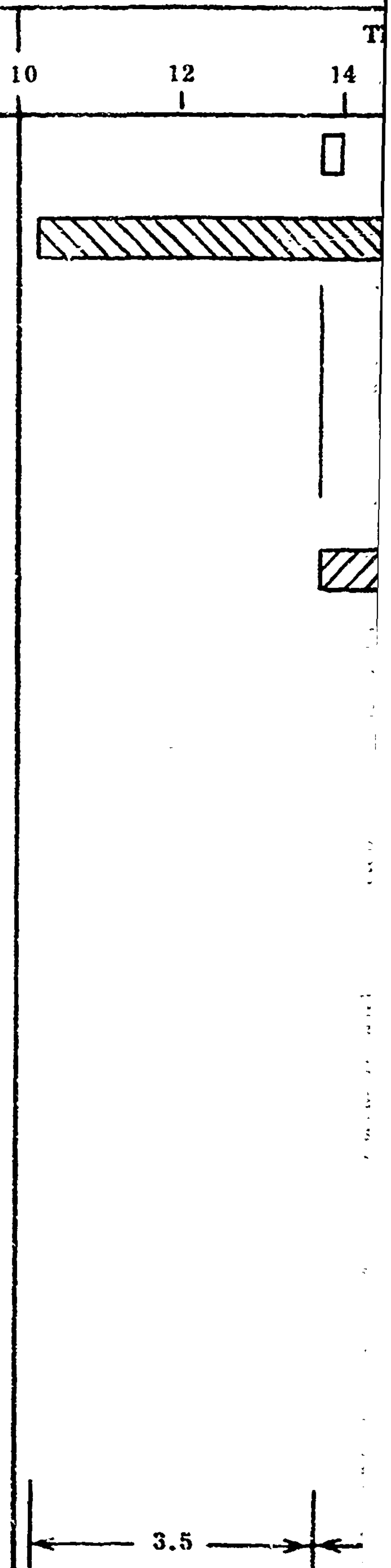
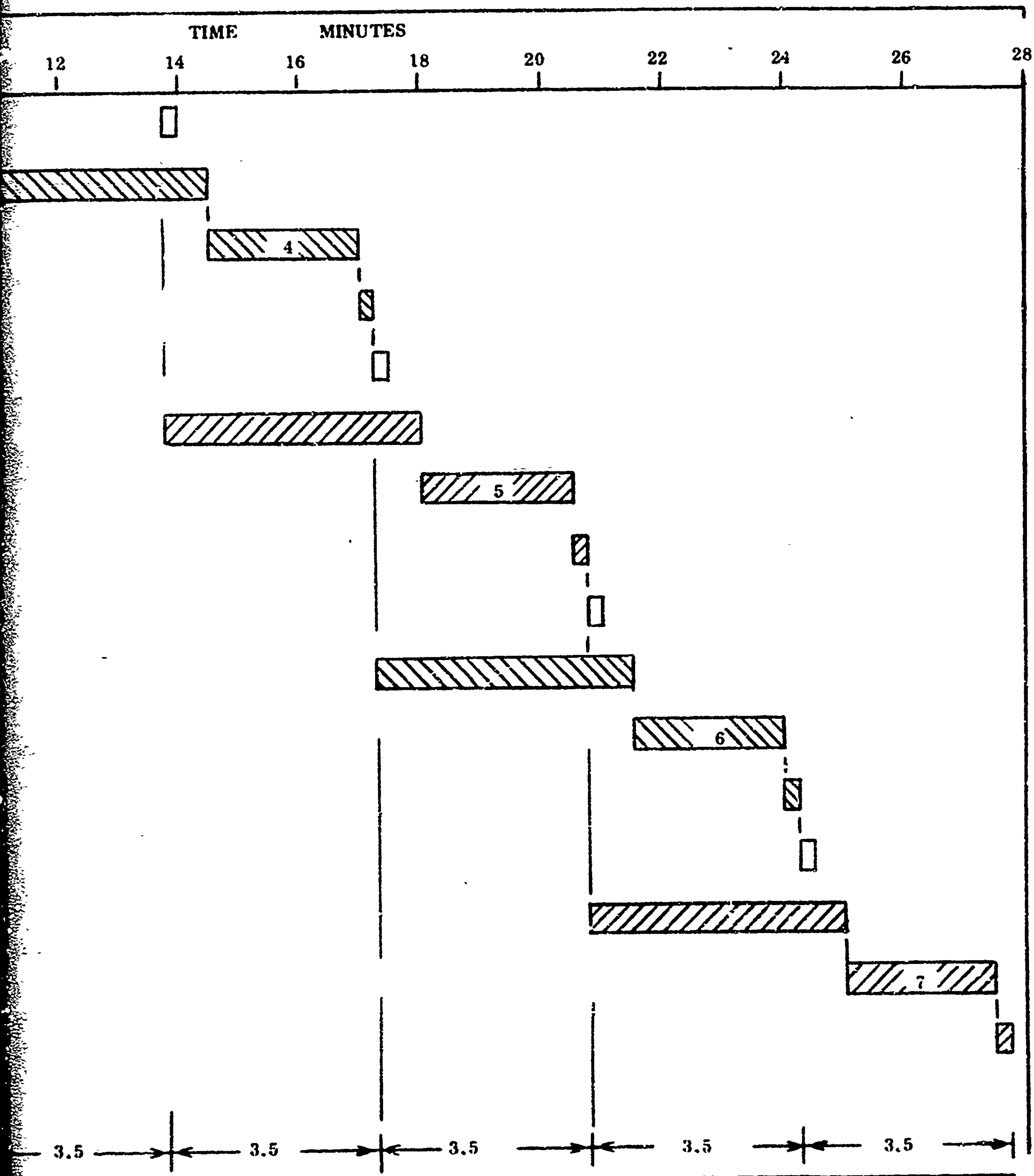


FIGURE 35. TIME SEQUENCE CHART - REARMING STATION BI-LEVEL

B



STATION BI-LEVEL MAKE-UP AREAS (Continued)

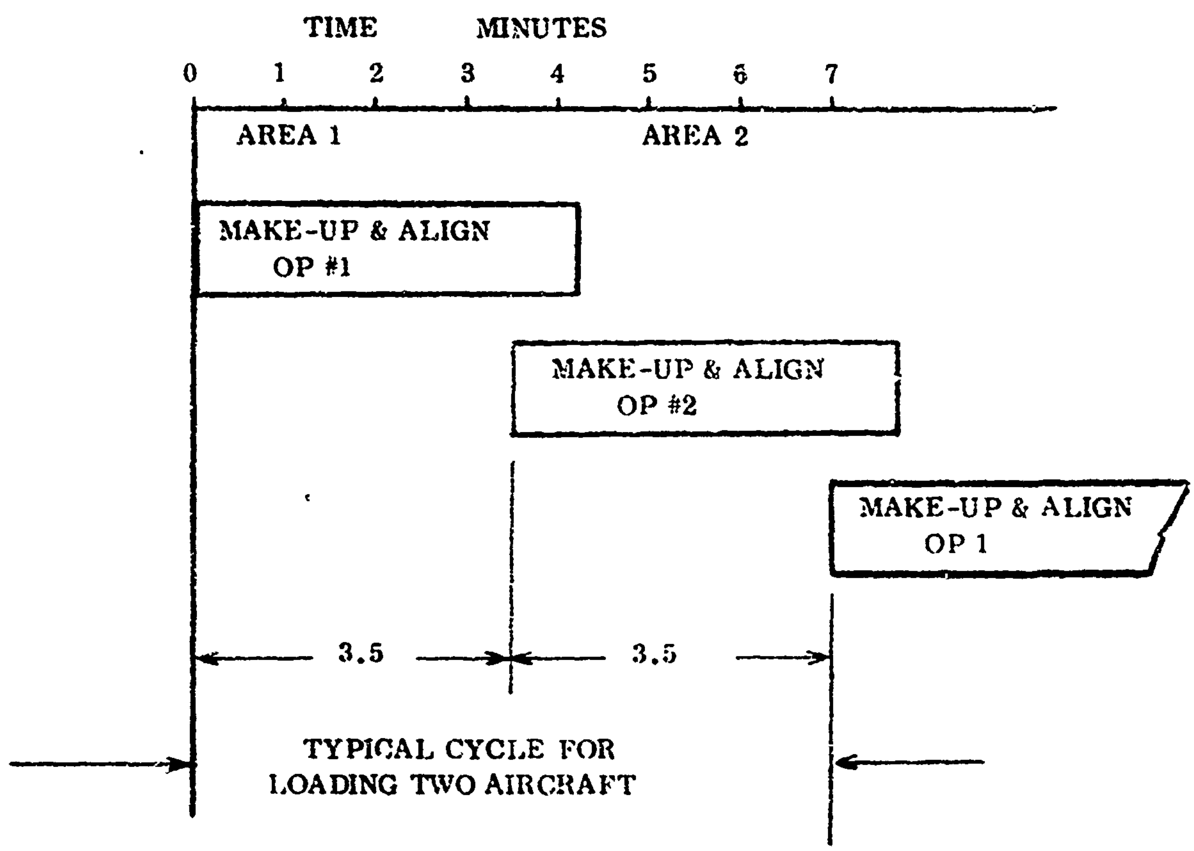


FIGURE 26. SEQUENTIAL REQUIREMENTS FROM WEAPONS STRIKE-UP VIEWPOINT

A number of techniques was investigated for shuttling the empty skids off and the loaded skids on the ordnance pallet. An inherent problem is that the empty-returning skids interfere with getting the loaded skids on the ordnance pallet.

One solution is to provide a temporary storage area for the empty skids; however, this solution uses valuable 03 level and 01 level ship volume.

Another solution is to cycle all empty skids to the main deck level, eject them, move the loaded skids on the ordnance elevators and raise them to the make-up area level. The "extra elevator cycle" technique delays the ordnance make-up and total weapons loading process and is therefore unattractive.

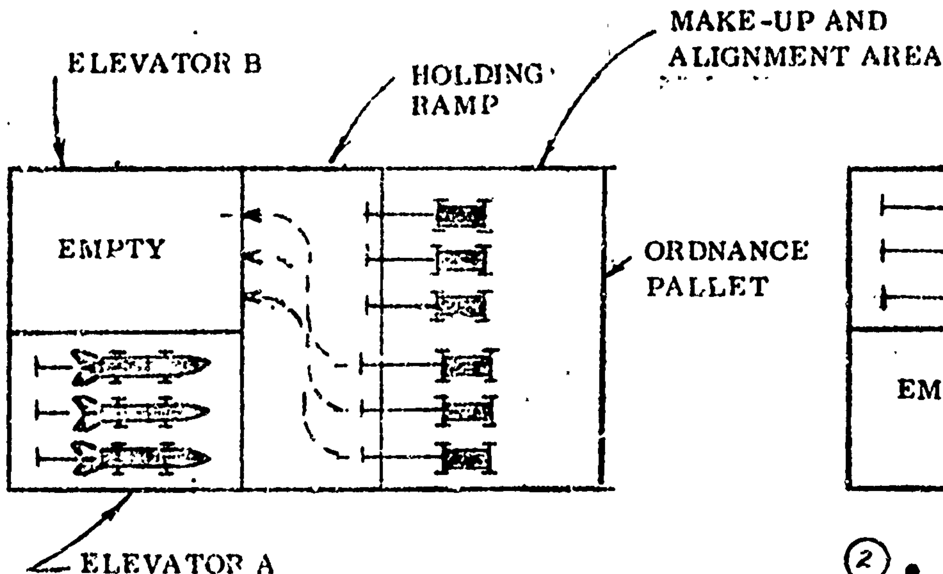
The technique selected for eliminating the skid interference problem is shown schematically in figure 37. Three empty skids are removed from a make-up area and cycled to the main deck, and three loaded skids are rolled onto the ordnance pallet. The second three empty skids are removed from the ordnance pallet and cycled to the main deck. While the first three loaded skids are positioned and aligned the remaining three loaded skids are delivered to the make-up area for positioning and alignment. This skid strike-up/strike-down technique eliminates delays in the make-up area and allows a longer time interval for elevators A and B to complete a cycle.

Figure 38 is a multiple activity chart of operations from the make-up area levels to the main deck. As mentioned earlier the technique for eliminating empty and loaded skid interference is one of the more critical operations. It can be noted that the idle time is evenly distributed and relatively small. At present operations of the pallet make-up crews are critical items which tend to limit the below deck operations. Some techniques for reducing the work load and speeding up the make-up and alignment operation are as follows:

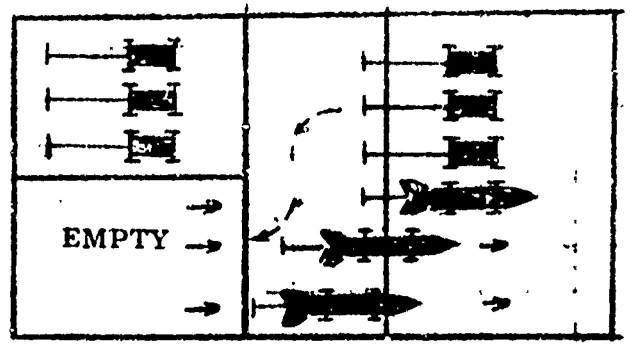
- Adding conveyors for moving the loaded skids from the elevator on to the ordnance pallet
- Providing automated and power driven mechanisms for moving the lift tables forward
- Incorporating power driven weapon support fixture adjustment mechanisms rather than using hand-driven mechanism
- Adding a feedback network for interfacing overhead alignment fixture read-out with weapon support fixture adjustment mechanisms.

Any of these modifications can be incorporated without changing the basic unit load rearming station design.

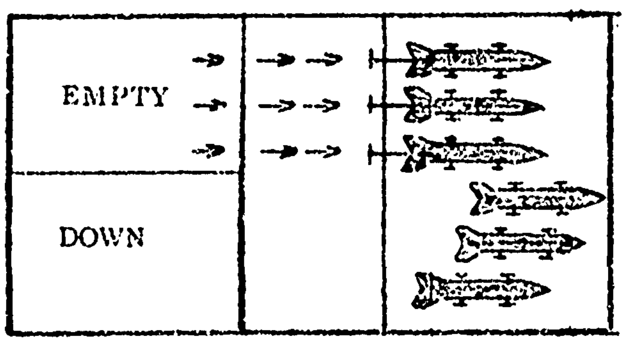
An item by item breakdown of below flight deck rearming operations which is contained in Flow Process Chart, figure 39



(1) INITIAL CONDITIONS 01 - LEVEL



(2)
- ELEVATOR B READY TO RETURN EMPTY SKIDS TO MAIN DECK
- 3 LOADED SKIDS MOVE FOR POSITIONING AND ALIGNMENT
- EMPTY SKIDS READY FOR LOADING ON ELEVATOR A



(3)
- FIRST 3 SKIDS ALIGNED
- OTHER SKIDS READY FOR ALIGNMENT PRIOR TO ORDNANCE PALLET MOVING WEAPONS LOAD TO AIRCRAFT

FIGURE 37. SEQUENCE OF EVENTS 01 LEVEL FOR ONE-HALF LOADING CYCLE

MULTIPLE ACTIVITY CHART

TIME MIN	MAIN DECK	U.S. ELEVATOR A 1	U.S. ELEVATOR B 1	MAKE-UP AREA 1 2	MAKE-UP AREA 2 3
INITIAL CO.	3 Loaded Skids Ready for Elevator B	At 01 - Level W/ 3 Loaded Skids	At 01 - Level Empty	Ord. Pallet #1 Returned with 6 Empty Skids	Final Alignment Made On Ord Pallet #2
0			Receives 3 Empty Skids 1	Ejects 3 Empty Skids 1	
		Ejects 3 Loaded Skids 2	Move to Main Deck	Receives 3 Loaded Skids 2	
1	Move Empty Skids from Elev. B & Move 3 Loaded Skids On		Eject 3 Empty Skids & Receive 3 Loaded Skids	Position & Secure Loaded Skids on WSF 3 & 4	
		Receives 3 Empty Skids 8		Align Loaded Skids & 5 6 & 7 Eject 3 Empty Skids 8	
		Move to Main Deck	Return to 01 - Level		
2	Move Empty Skids from Elev. A & Move 3 Loaded Skids On	Eject 3 Empty Skids & Receive 3 Loaded Skids	Eject 3 Loaded Skids 9	Receive 3 Loaded Skids 9	
				Position & Secure Loaded Skids on WSF 10 11	
3			Move to 03 Level	Align Remaining 3 Loaded Skids 12 13 14	
		Move to 03 Level			

8

3			03 Level	Align Remaining 3 Loaded Skids (12) (13) (14)	
		Move to 03 Level			
			Receives 3 Empty Skids		Ejects 3 Empty Skids
		Ejects 3 Loaded Skids	Move to Main Deck	Ord. 1 . Moved On Rearming Elev. & Final Adj. Made 15 & 16	Receives 3 Loaded Skids
1	Move Empty Skids from Elev. B & Move 3 Loaded Skids On		Eject 3 Empty Skids & Receive 3 Loaded Skids		Position & Secure Loaded Skids on WSF
				CREW #1 Stationed on Ord. Pallet Controls & Verifies Weapons Loading & Makes Necessary Hardware Adjustments (17) (25)	
		Receives 3 Empty Skids			Align Loaded Skids & Eject 3 Empty Skids
5					
		Move to Main Deck	Return to 03 Level		
			Eject Loaded Skids		Receive 3 Loaded Skids
6	Move Empty Skids From Elev. A & Move 2 Loaded Skids On	Eject 3 Empty Skids & Receive 3 Loaded Skids			Position & Secure Loaded Skids on WSF
			Move to 01 - Level		Align Remaining 3 Loaded Skids
7		Move to 01 Level		Ord Pallet Returns to Area (26)	

END OF ONE TYPICAL BELOW FLIGHT DECK OPERATION

NOTES:

5		Receives 3 Empty Skids		Pallet Controls & Verifies Weapons Loading & Makes Necessary Hardware Adjustments (17) (25)	Align Loaded Skids & Eject 3 Empty Skids
	Move Empty Skids From Elev. A & Move 3 Loaded Skids On	Move to Main Deck	Return to 03 Level		
6		Eject 3 Empty Skids & Receive 3 Loaded Skids	Eject Loaded Skids		Receive 3 Loaded Skids
					Position & Secure Loaded Skids on WSF
			Move to 01 - Level		Align Remaining 3 Loaded Skids
7		Move to 01 - Level		Ord Pallet Returns to Area (26)	

END OF ONE TYPICAL BELOW FLIGHT DECK OPERATION

NOTES

1. U.S. ELEVATORS UNMANNED AND CONTROLLED FROM MAIN DECK LEVELS AND MAKE-UP AREAS.

2. MAKE-UP AREA NO. 1 OPERATIONS REQUIRE 3 TWO MAN ORDNANCE HANDLING TEAMS PLUS ONE MAKE UP AREA COORDINATOR & CONTROLLER

3. MAKE-UP AREA NO. 2 OPERATIONS REQUIRE 3 TWO MAN ORDNANCE HANDLING TEAMS PLUS ONE MAKE-UP AREA COORDINATOR & CONTROLLER.

(N) FOR ADDITIONAL DETAILS REFER TO FLOW PROCESS CHART FIGURE 5. N DESIGNATES FLOW CHART SEQUENCE NUMBER.

FIGURE 38. MULTIPLE ACTIVITY CHART - 03 LEVEL TO MAIN DECK OPERATIONS

Seq. No.	PROCESS/TASK	Man Level	Distance X	Y	Z	Time (Sec)	Symbol	Elapsed Time (Min)
	Ord. Pallet #1 in make-up area with 6 empty skids. Elevator B up and empty. Elevator A up and loaded 3 skids.						Start	0
1.	3 empty skids moved from WSF onto Elevator B	6	30'	-	-	15	1	
2.	3 loaded skids moved off elevator on holding ramp	6	20'	-	-	15	2	
3.	3 loaded skids moved onto WSF, lock-down latches automatically operate	6	10'	-	-	20	3	
4.	Verify that skids are properly secured		-	-	-	10	1	
5.	Lift tables moved forward, + X on ord. pallet to fixed position for A/C	6	8'	-	-	10	4	
6.	Lift tables adjusted to align ord. lugs to overhead alignment fixtures, Z, Y & X.	3	4"	2"	3'	45	5	
7.	Lift Tables locked to ord. pallet	3	-	-	-	05	1	
8.	3 empty skids moved from WSF onto elevator A	3	30	-	-	30	6	2.0
9.	3 loaded skids moved from elevator B to holding ramp	3	20	-	-	15	7	
10.	3 loaded skids moved onto WSF, lock-down latches operate automatically	6	10	-	-	20	8	

FIGURE 39. FLOW PROCESS CHART

Seq No.	PROCESS / TASK	Man Level	Distance X	Distance Y	Distance Z	Time (Sec)	Symbol	Elapsed Time (Min)
11.	Verify that skids are properly secured	6	-	-	-	10	2	
12.	Lift tables moved FWD ! X on Ord. pallet to fixed position for A/C	6	8'	-	-	10	9	
13.	Lift tables adjusted to align Ord. lugs to overhead alignment fixtures, Z, Y & X	3	4"	2"	3'	45	10	
14.	Lift tables locked to Ord. pallet					05		
15.	Ordnance pallet moved onto elevator and secured	6	40'			20	11	
16.	(For A-7 Only) Base of lift tables Sta 1, 2 & 3 locked together and STA 6, 7 & 8 locked together. Three outboard tables moved outboard 27" and locked	6	-	27"	-	10	12	4.25
17.	Ordnance elevator raises ordnance load to flight deck level	6	-	-	23'	25	13	4.25
18.	"Locked Together" lift tables moved inward 27" and secured (A-7 Only)	6	-	27"	-	10	14	
19.	Verify final alignment adjust WSF as necessary	6	-	-	-	40	3-3	
20.	Raise lift tables final two inches and load weapons	6	-	-	2"	10	15	

FIGURE 39. FLOW PROCESS CHART (Cont'd)

Seq. No.	PROCESS/TASK	Man Level	Distance X	Distance Y	Distance Z	Time (Sec)	Symbol	Elapsed Time (Min)
21.	Release weapons to skid tie-down (solenoid actuated)	6				05	4	
22.	Lower lift tables slightly and verify that weapons are loaded and perform final safety checks	6				05	5	
						25		
23.	"Locked Together" lift tables moved outward 27" and secured		-	27"	-	10	16	
24.	Elevator lowers empty skids to make-up area #1 (lift tables are lowered and moved to rear of ordnance pallet as elevator is lowered.		-	-	23	20	17	6.75
25.	Ordnance pallet ejected from elevator.		30			15	18	7.0

FIGURE 39. FLOW PROCESS CHART (Cont'd)

is based upon the "worst case loading" of the A-7 aircraft. A high degree of flexibility of individual operations exists without changing the overall loading schedule.

3. Flight Deck and Overall Operations

a. Introduction

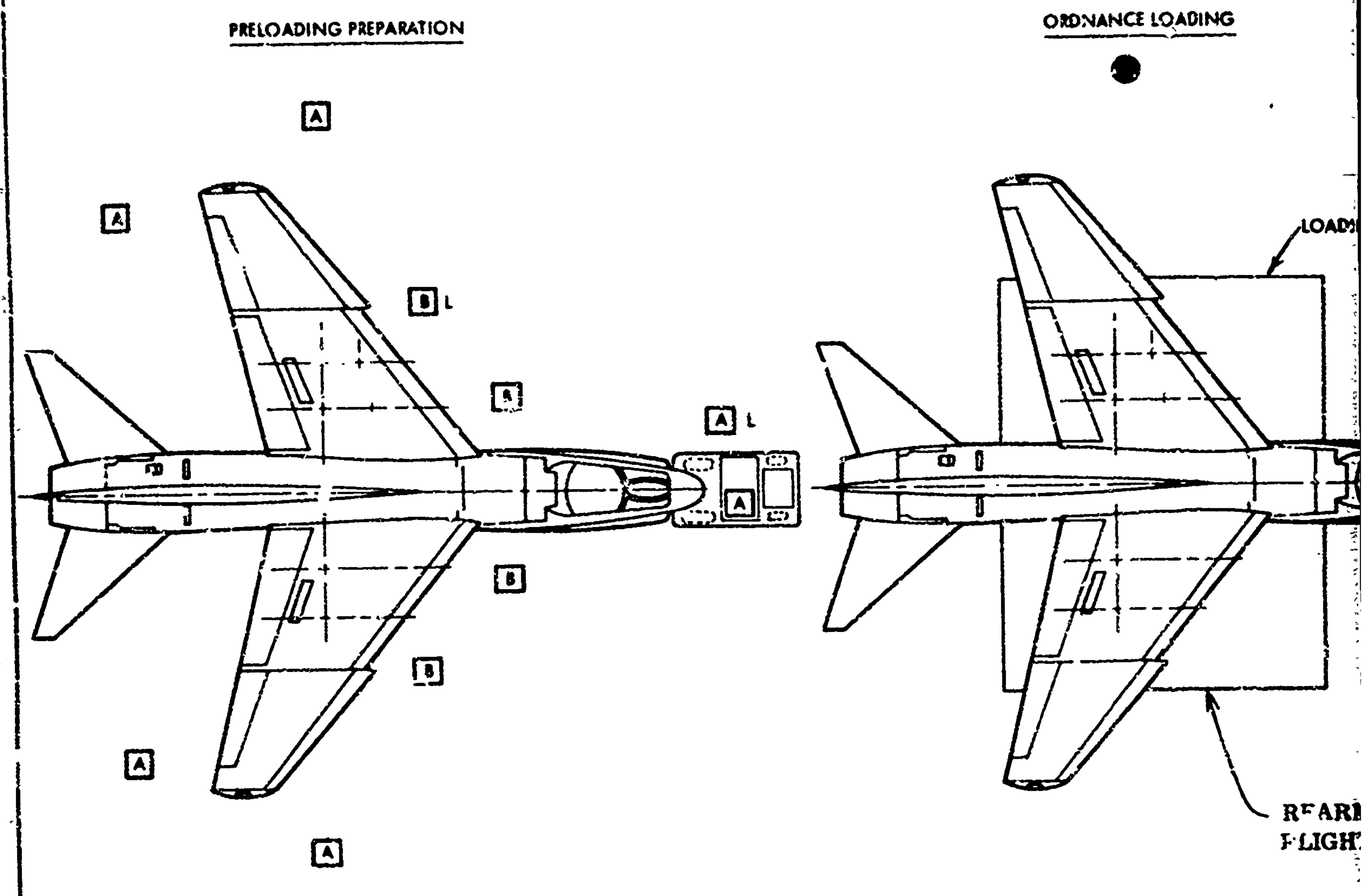
This section defines the work crews, and operations on the flight deck and the overall operations of a baseline weapons loading station.

b. Manpower and Crew Data

The manpower and crew make-up necessary for accomplishing flight deck operations are as outlined in figure 40 and as defined below.

Table 6. Baseline Rearming Station Flight Deck Manpower

Operation	Crew Designation	Manpower
(1) Move a preconfigured aircraft spotted on the flight deck outside the loading station.	A	2 Tow Truck Drivers 2 Assistants 4 Wing Walkers
(2) Perform preloading preparation (outside rearming station) equivalent to that outlined by reference 16.	B	4 Preloading Specialists
(3) Ordnance loading supervision/ coordinator.	-	1 Loading Officer
(4) Perform post loading preparation equivalent to that outlined by reference 16.	C	4 Post Loading Specialists
(5) Move loaded aircraft and spot on flight deck for launch.	A	2 Tow Truck Drivers 2 Assistants 4 Wing Walkers
Rearming Personnel on Flight Deck		25

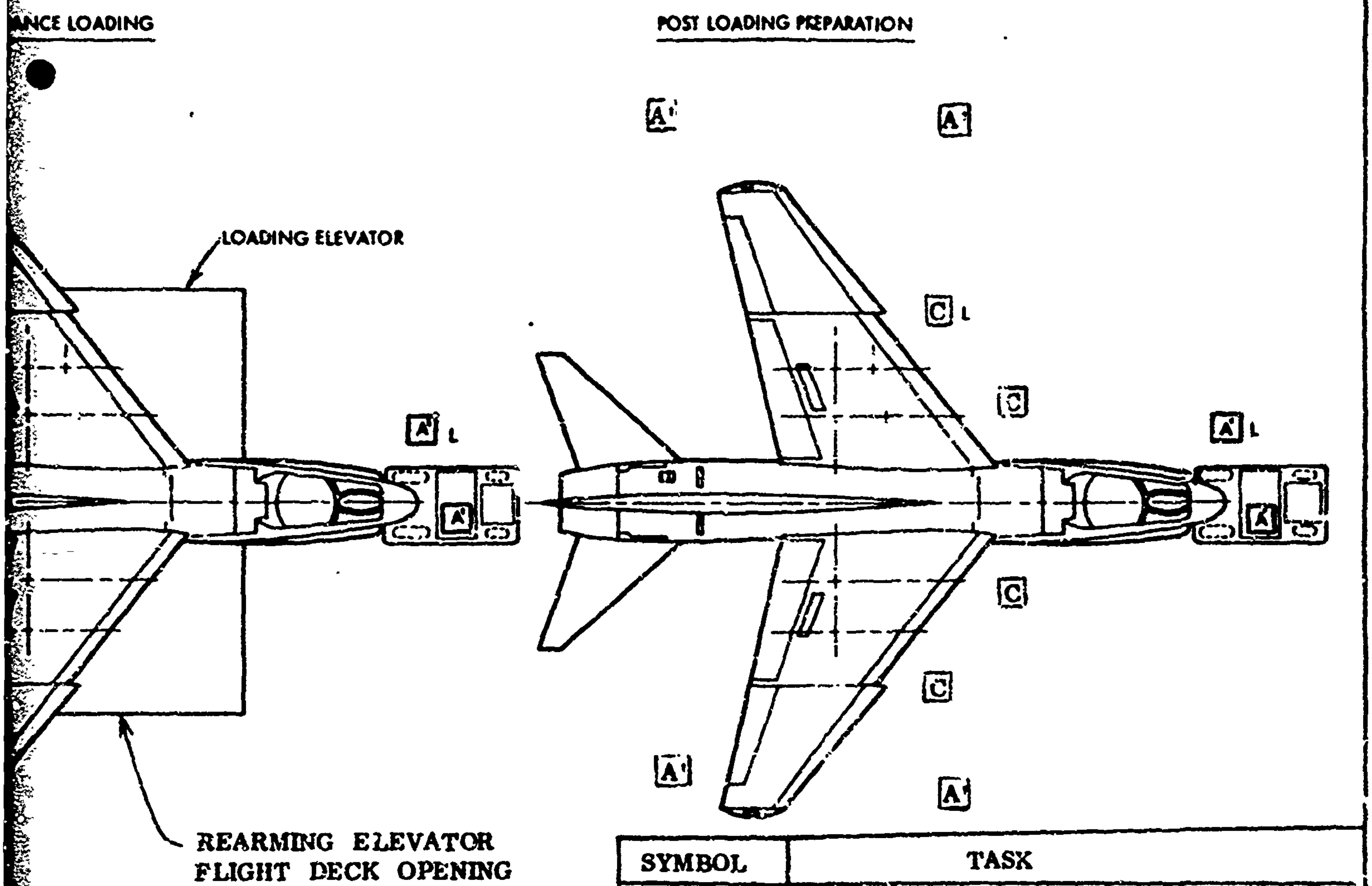


NOTE:

ONE TOW TRUCK DRIVER AND ONE ASSISTANCE OF TEAM "A" ARE HOOKING UP TO NEXT AIRCRAFT AND ARE NOT SHOWN IN THIS FIGURE.

FIGUR

B



SYMBOL	TASK
A and A'	AIRCRAFT MOVERS
B	PRELOAD PREPARATION
C	POST LOADING PREPARATION
●	ORDNANCE LOADING OFFICER
L	DESIGNATES CREW LEADER

FIGURE 40. FLIGHT DECK WORK STATIONS FOR UNIT LOAD REARMING STATION

The manpower and crew make-up to support the unit loader below the flight deck were defined in the preceding section, table 5. Twelve workmen and two coordinators/controllers constitute the below flight deck manpower for the weapons station. The manpower for operating one weapons loading station is estimated to be thirty-nine, 25 on flight deck, 14 below flight deck.

c. Sequence of Operations

An operational sequence of events has been established which relates activities on the flight deck and in the make-up areas. The time for the major operations of the baseline rearming station is shown in figure 41. These time estimates were obtained by breaking down the individual movements of workmen and equipment and are believed to be conservative with a potential for further optimization.

The interrelationships of the rearming station are a critical factor. That is, change of one operational method, sequence, or time can have a "snowballing" effect on other functions and the overall loading time, ship volume and manpower required. In developing an overall sequence of events several iterations were necessary to arrive at a synchronization of on flight deck operations and below flight deck operations. In some cases speeding up one operation actually resulted in a conflict of hardware flow/manpower availability and resulted in reducing the overall loading efficiency. Figure 42 is a simplified sequence of rearming station events relating weapons flow and aircraft movements.

Time (Sec)	Aircraft (A/C)	Unit Loader (U/L)	Time (Sec)
-	Start - Fueled aircraft are spotted on flight deck preconfigured for next bomb load	Start - Empty Loader is in make-up area.	-
180	A/C No. 1 moved outside rearming station	Ordnance loaded on U/L and aligned using alignment fixture	235
120*	A/C preloading preparation and inspection	U/L moved into position and secured on elevator	20
60*	A/C secured to rearming station and unhooked from tow truck	U/L moved to flight deck	25
40	A/C moved into position and secured for loading		
105	A/C receives ordnance	Final adjustments of U/L to A/C and ordnance loaded on A/C	105
35	A/C unlatched & moved from rearming station	Empty U/L lowered	20
120	Post loading preparation and final inspections	U/L returned to make-up area	15
180	Loaded A/C spotted on deck ready for launch		
60	Recycle tow truck for A/C	Repeat above	-
	* Parallel Operations		
840 Sec (14 Min)	Cycle Time for one A/C	Cycle for one make-up area	420 Sec. (7.0 Min)

FIGURE 41. OPERATIONAL PROCESS CHART - BASELINE REARMING STATION

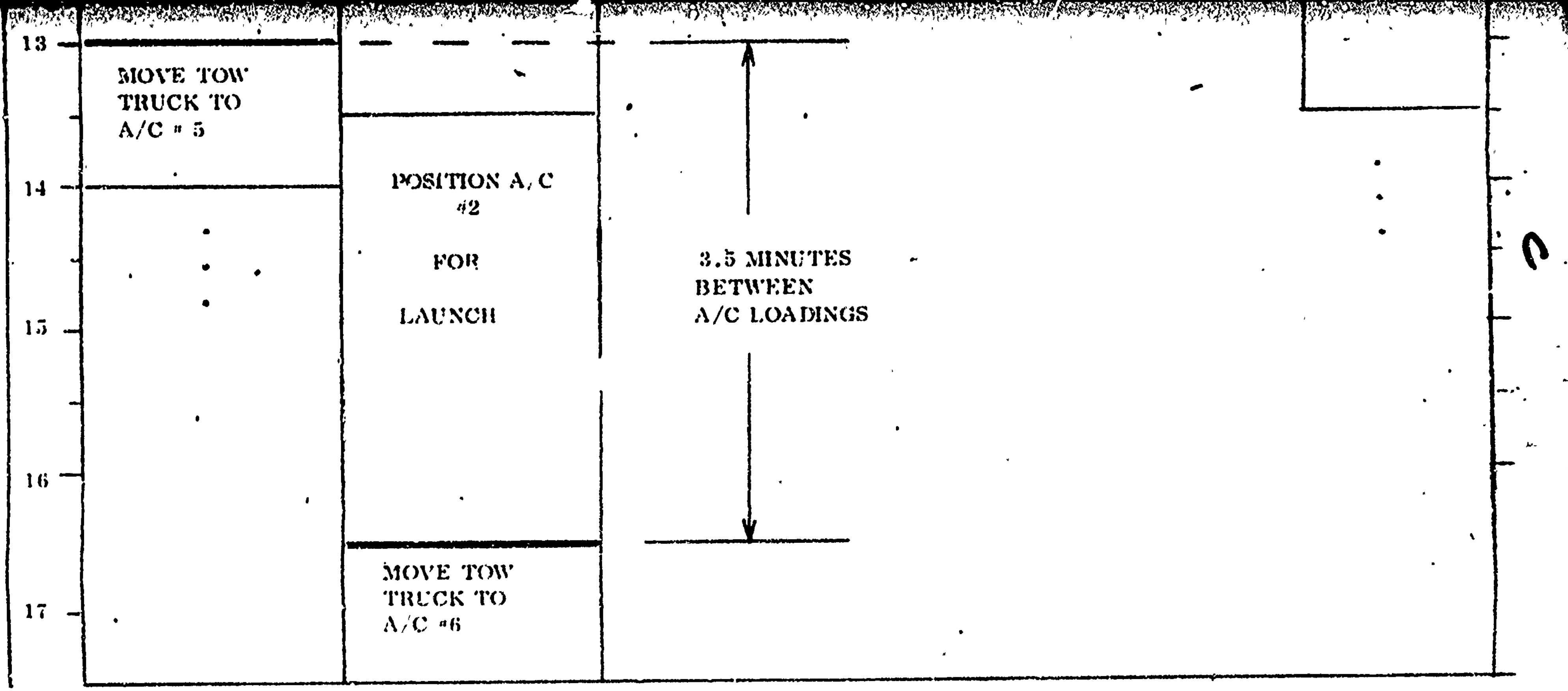
A multiple activity chart of the overall loading operations for one typical cycle is shown by figure 43. This activity chart forms a baseline sequence of operation for use and further optimization as the rearming station hardware is developed.

A

Time Min	FLIGHT DECK			BELOW FLIGHT DECK		FLIGHT DECK
	AIRCRAFT HANDLERS		PRELOADING	PALLET MAKE-UP, ALIGNMENT & ORD LOADING		POST LOADING
①②	CREW A	CREW A′	CREW B	CREW #1	CREW #2	CREW C
INITAL COND.	AIRCRAFT FUELED & SPOTTED ON DECK		READY	ORD PALLET #1 IN MAKE-UP AREA #1	ORD PALLET IN MAKE-UP AREA #2	READY
0 – 1	MOVE A/C #1 TO PRELOADING STATION					
1 – 3				MAKE-UP ORD PALLET, ALIGN WEAPONS MOVE ORD. PALLET #1 ON ELEVATOR		
3	HOOK A/C TO TOW SYSTEM					
3.5	UNHOOK & MOVE TOW TRUCK	MOVE A/C #2 TO PRELOADING STATION	PRELOAD PREPARATION A/C #1			
5	MOVE & SECURE					

B

	MOVE & SECURE A/C #1 ON L.S. STAND BY DURING LOADING OPERATIONS	STATION		RAISE OP. #1	MAKE-UP ORD. PALLET. ALIGN WEAPONS MOVE ORD PALLET #1 ON ELEVATOR	
6		HOOK A/C TO TOW SYSTEM	PRELOAD PREPARATION A/C #2	MAKE FINAL ADJUSTMENTS & LOAD WEAPONS ON A/C #1		
7	MOVE A/C #1 OUT OF LS	UNHOOK & MOVE TOW TRUCK		LOWER OP #1 OP #1 RETURN TO MAKE-UP AREA 1		
8		PREP STATION FOR A/C #2 MOVE & SECURE A/C #2 ON LS			RAISE OP #2	POST LOADING PREPARATION A/C #1
9		STANDBY DURING LOADING OPERATIONS			ADJ & LOAD WEAPONS ON A/C #2	
10	POSITION A/C #1 FOR LAUNCH					
11		MOVE A/C #2 OUT OF LS			LOWER OP #2 RETURN OP #2 TO MAKE-UP #2	POST LOADING PREPARATION A/C #2
12						
13	MOVE TOW TRUCK TO A/C #5	POSITION A/C				
14						



NOTES

① Crew and work team make-up are as outlined in previous tables E-1 and E-2.

② Time sequence based upon typical "worst case" loading of A-7 aircraft as defined in Section V.E.2.

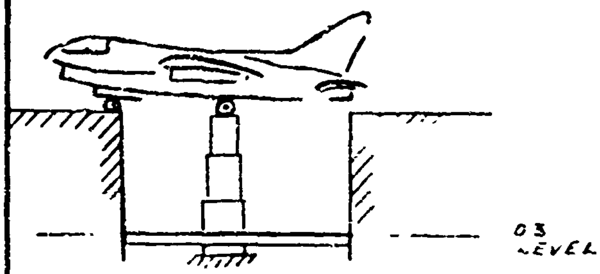
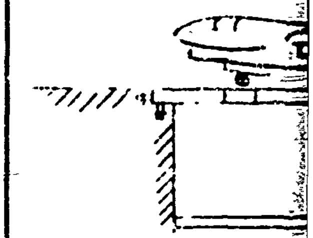
FIGURE 43. . MULTIPLE ACTIVITY CHART - OVERALL LOADING OPERATIONS FOR ONE TYPICAL CYCLE - BASELINE REARMING STATION

APPENDIX

A-I. SELECTION OF ALIGNMENT AND SUSPENSION CONCEPT DATA

This Appendix contains data used in the selection of baseline concepts for supporting the aircraft over the rearming station and for aligning the aircraft and weapons pallet.

FIGURE A-1 - COMPARISON OF AIRCRAFT SUS

Concept / Item	Importance of Item Rating (IR)	Column Support			Guide Ra	
General Concept						
		Rating	IR x Rating	Data	Rating	IR x
1 Structural, Design	1					
a. Weight, Str. Only		2	2		1	
• Flight Deck				-0-		
• 03 Level				6100 lbs		
b. Rigidity		2	2		2	
2. System Simplicity	3					
a. Design Simplicity -Cost Impact Item		2	6		3	
b. Operational Simplicity— Skill Required		3	9		2	
c. Serviceability		3	9		2	
3. Operational Flexibility	3					
a. Nominal Operation		3	9		2	
b. Manual Back-up Capability		3	9		3	
c. System Improvement Potential		2	6		3	
Subtotal			52			4

B
AIRCRAFT SUSPENSION CONCEPTS

CHD	8/5/71	DHG	1/3

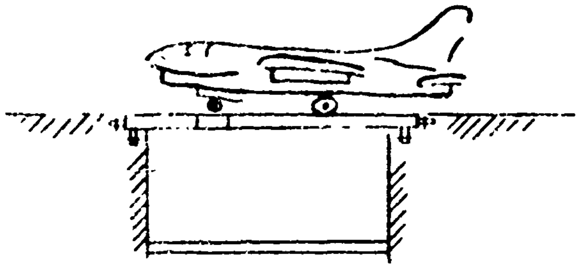
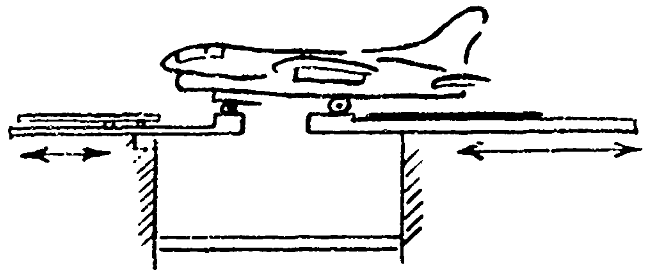
GUIDE RAILS SUPPORT			EXTENDIBLE BEAMS & BRIDGE SUPPORT		
					
RATING	IR X RATING	DATA	RATING	IR X RATING	DATA
1	1		2	2	
		9100 LBS -0-			9100 LBS -0-
2	2	LIMITS OF DEFLECTION 1/2 INCH	2	2	LIMITS OF DEFLECTION 1/2 INCH
3	9		2	6	
2	6		1	3	
2	6		1	3	
2	6		1	3	
3	9		1	3	
3	9		1	3	
	48			25	

FIGURE A-1 – COMPARISON OF AIRCRAFT SUSPEN

ITEM / CONCEPT	IR	COLUMN SUPPORT			GUIDE RAIL	
		RATING	IR X RATING	DATA	RATING	IR X RAT
4. VULNERABILITY OF STATION	2					
a. FLIGHT DECK						
FIRE & EXPLOSION		3	6		2	4
b. 03 LEVEL						
FIRE & EXPLOSION		1	2		2	4
5. SAFETY/HUMAN ENG'R	3	3	9		2	6
ON-DECK & BELOW DECK						
6. RELIABILITY & MAINTAINABILITY	3	2	6		2	6
RESISTANCE TO NORMAL CARRIER ENVIRONMENT.						
7. TIME REQUIREMENTS*	2					
a. TIME TO SERVICE FIRST A/C		2	4	13.5 MIN.	3	6
b. TIME BETWEEN SERVICING		2	4	5.5 MIN.	3	6
8. MANPOWER REQ'D*	3	3	9		3	9
ON-DECK				25		
TOTAL				39		
* BASED ON ONE UNIT LOADING STATION						
SUBTOTAL			40			41

B

AIRCRAFT SUSPENSION CONCEPTS (CONT)

CHD | 8/5/71 | ~~SHD~~ | 2/3

	GUIDE RAILS SUPPORT			EXTENDIBLE BEAMS & BRIDGE SUPPORT		
	RATING	IR X RATING	DATA	RATING	IR X RATING	DATA
	2	4		1	2	
	2	4		2	4	
	2	6		2	6	
	2	6		1	3	
N.	3	6	13 MIN.	3	6	13 MIN.
N.	3	6	3.0 MIN.	3	6	3.0 MIN
	3	9		3	9	
			25			25
			39			39
		41			36	

FIGURE A-1 – COMPARISON OF AIRCRAFT SUSP

CONCEPT / ITEM	IR	COLUMN SUPPORT			GUIDE RA	
		RATING	IR X RATING	DATA	RATING	IR X R
9. IMPACT ON ASSOCIATED SYSTEMS DOES A/C SUPPORT CONCEPT ALLOW DESIGN & OPERATIONAL FLEXIBILITY OF ASSOCIATED SYSTEMS? IMPACT RATING ON:	2					
a. AIRCRAFT ORDNANCE ALIGNMENT SYS.		2	4		1	
b. ON-DECK LOADING OPERATIONS		3	6		2	
C. BELOW DECK SUPPORT OPERATIONS – INCUDING UNIT LOADER		1	2		3	
d SHIP DESIGN		1	2		3	
SUBTOTAL			14			
TOTAL – CONCEPT RATING			106			1[illegible]

IMPORTANCE OF ITEM RATING

3 VERY CRITICAL

2 IMPORTANT

1 NOT CRITICAL – FLEXIBLE

B

RCRAFT SUSPENSION CONCEPTS (CONT)

CHD	8/5/71	DHB	3/3

GUIDE RAILS SUPPORT			EXTENDIBLE BEAMS & BRIDGE SUPPORT		
RATING	IR X RATING	DATA	RATING	IR X RATING	DATA
1	2		2	4	
2	4		2	4	
3	6		3	6	
3	6		3	6	
	18			20	
	107			81	

ITEM RATING (IR)

AL

AL- FLEXIBLE

CONCEPT RATING

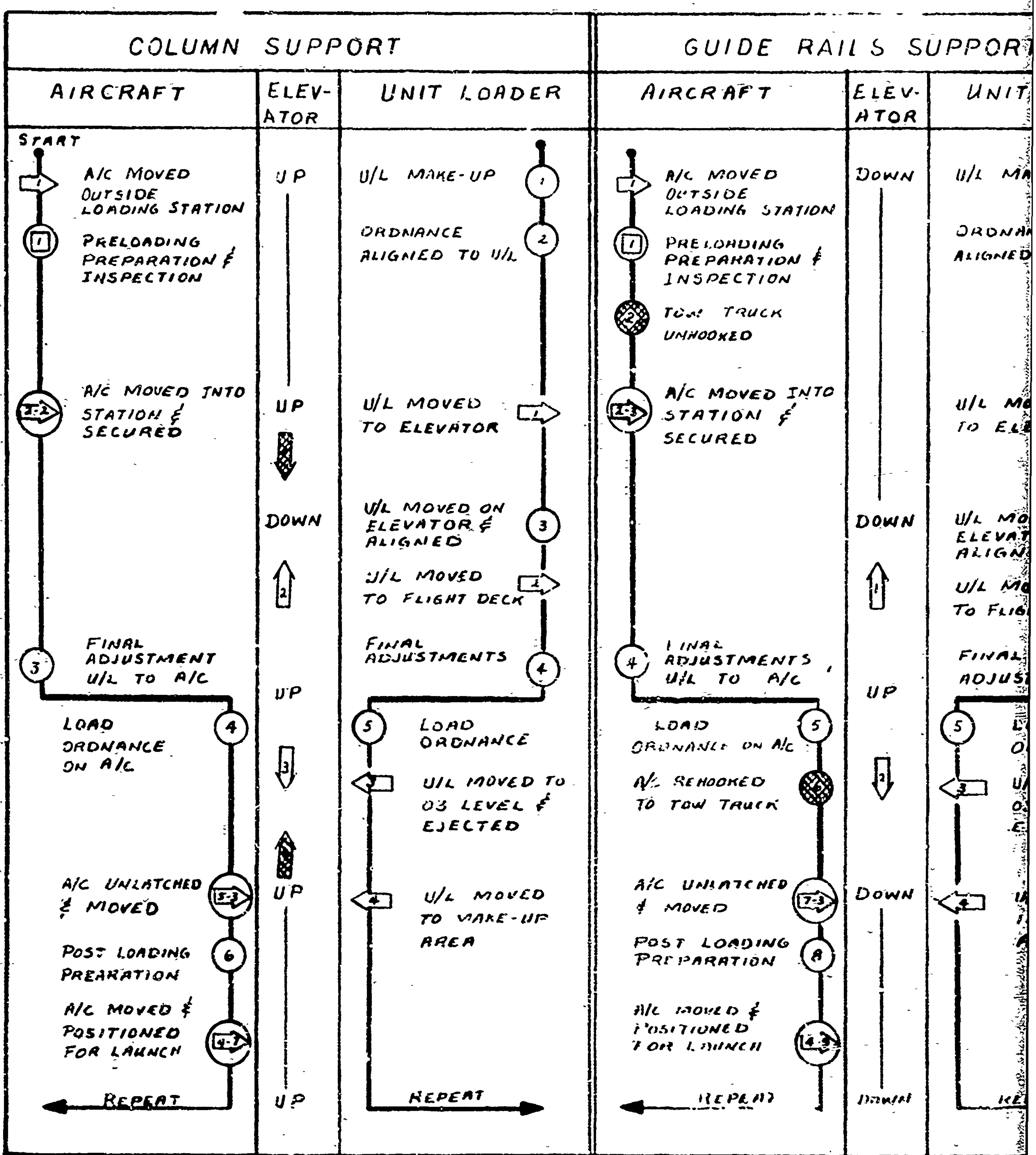
3 SUPERIOR CONCEPT

2 EXCELLENT CONCEPT- ONLY MINOR REFINEMENTS REQUIRED

1 WORKABLE BUT LIMITED CONCEPT (FROM VIEWPOINT OF THE ITEM)

4

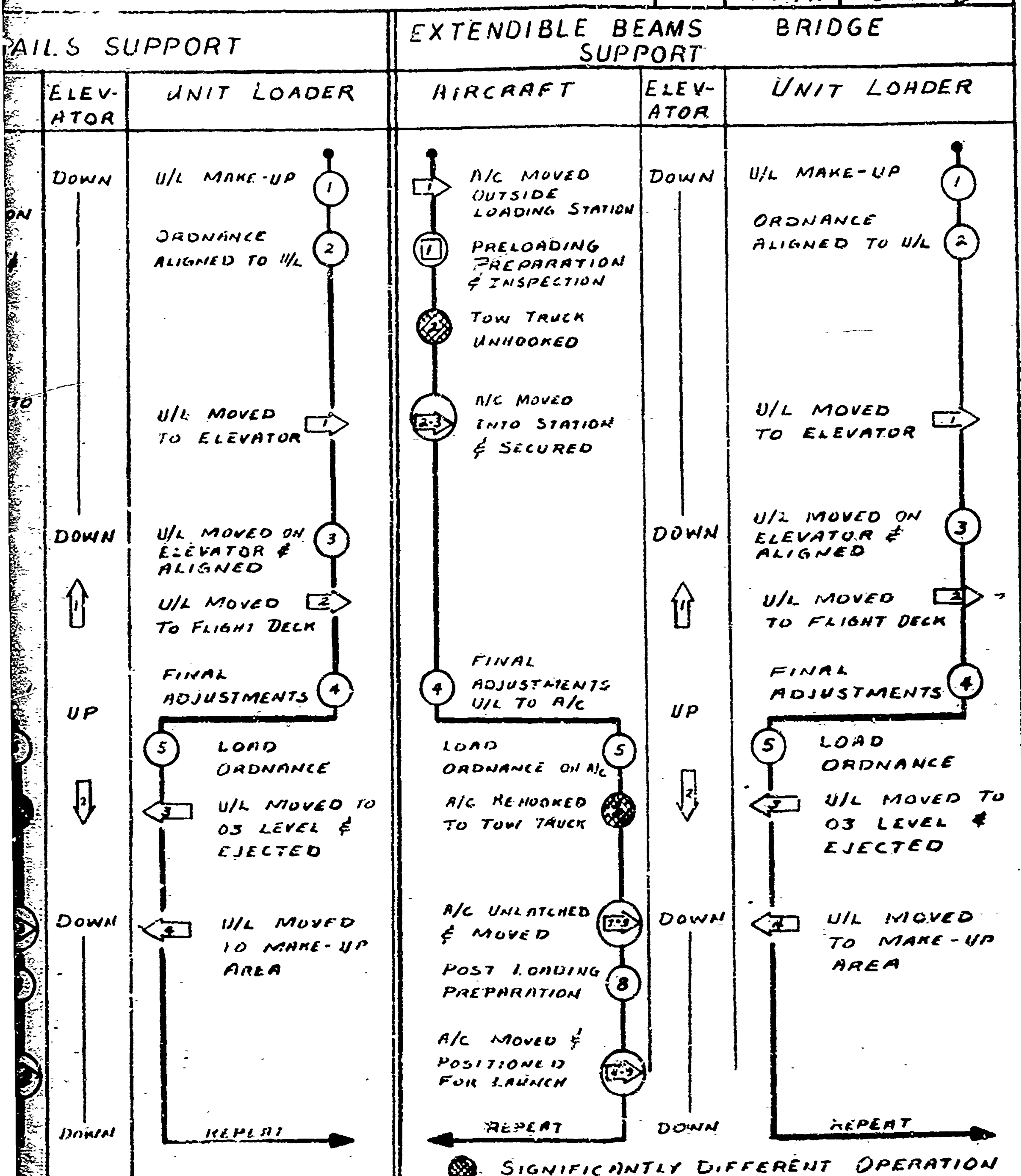
FIGURE A-2 - OPERATIONAL COMPARISON OF AIRCRAFT



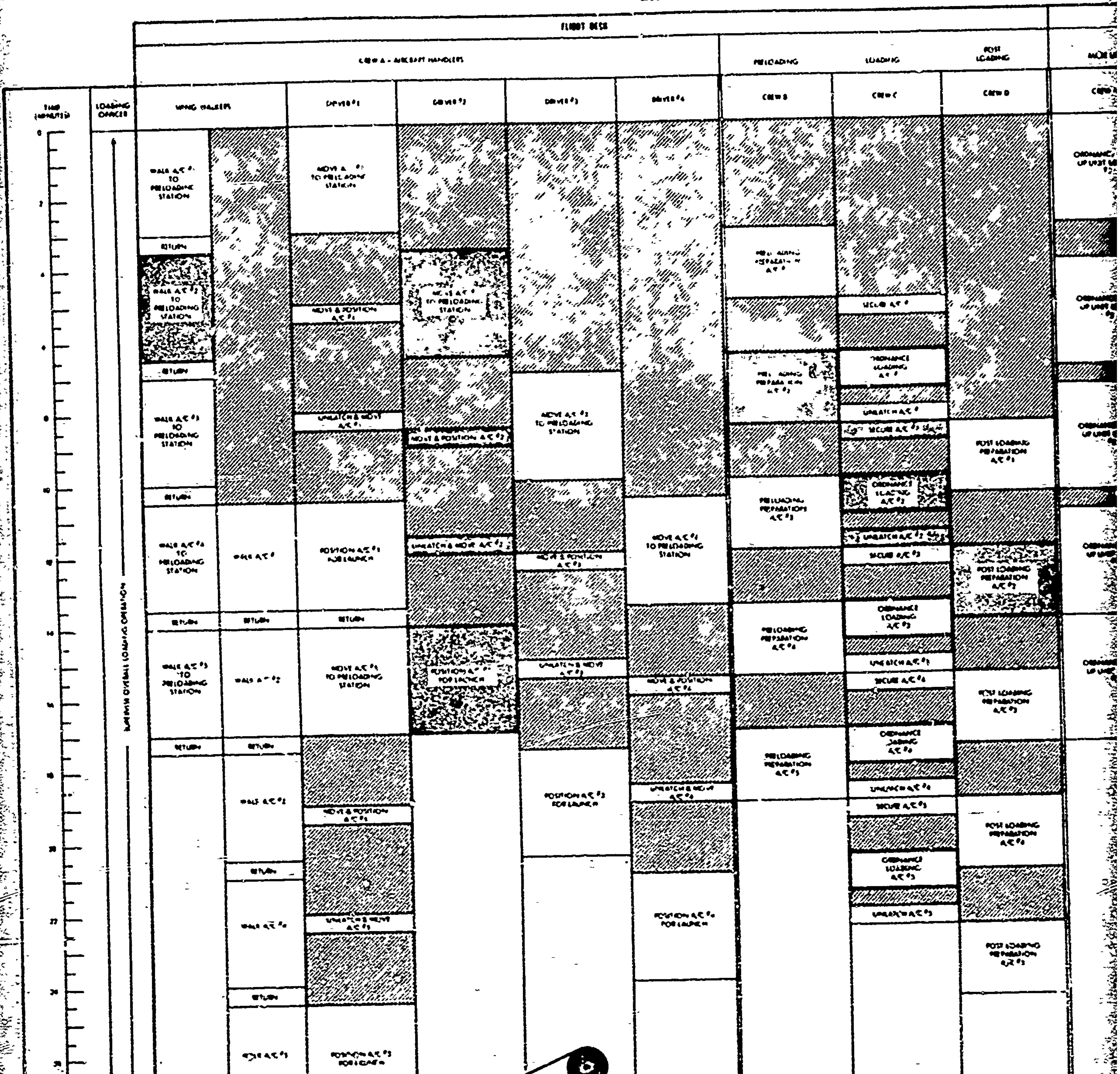
B

01 AIRCRAFT SUPPOPT SYSTEMS

CHD	7/20/71	DHO	1/1



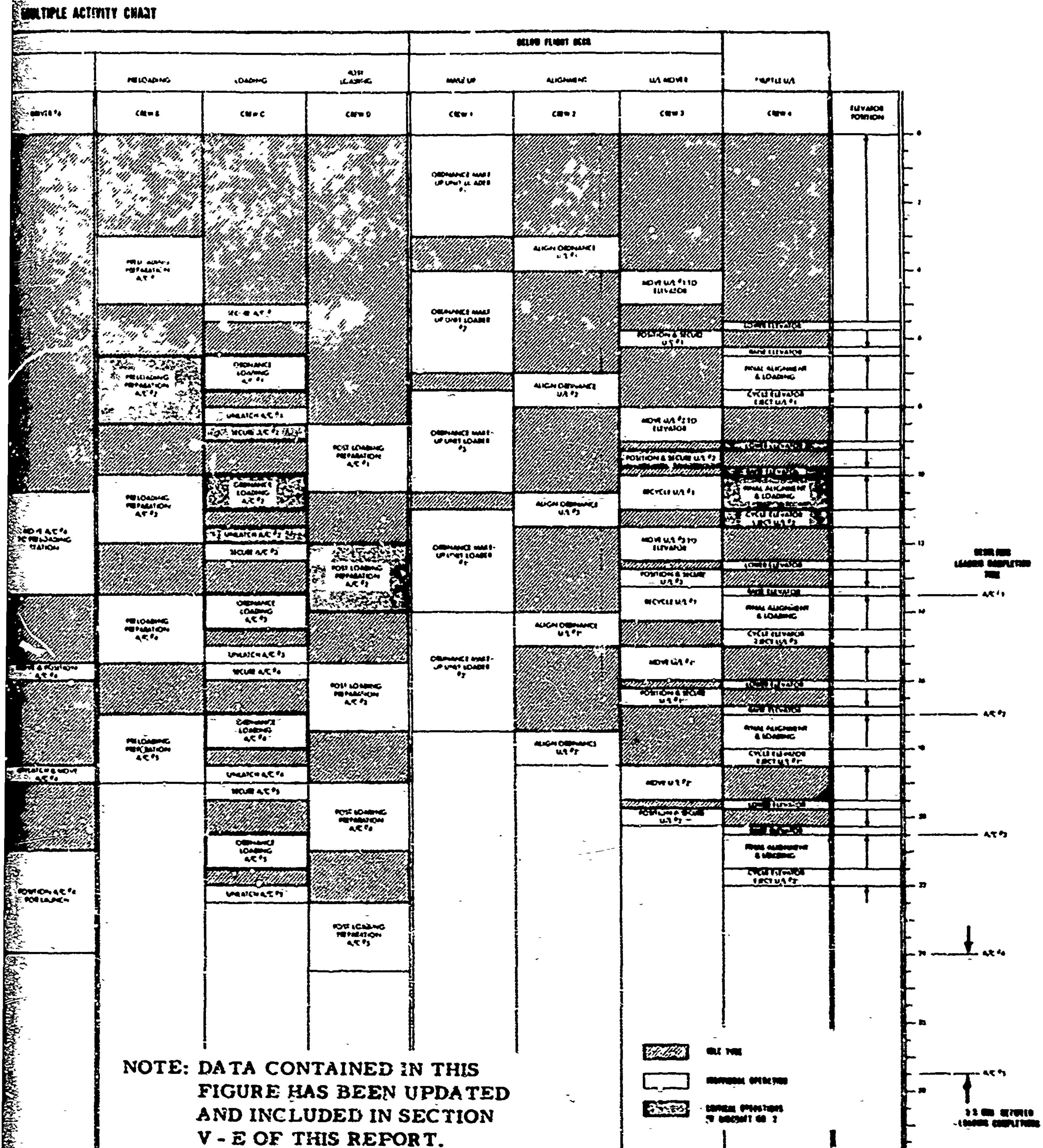
MULTIPLE ACTIVITY CHART



NOTE: DATA CONTAINED IN T
FIGURE HAS BEEN UPD
AND INCLUDED IN SECT
V - E OF THIS REPORT.

FIGURE A-3 REARMING OPERAT
MULTIPLE ACTIVITY

B



NOTE: DATA CONTAINED IN THIS FIGURE HAS BEEN UPDATED AND INCLUDED IN SECTION V - E OF THIS REPORT.

FIGURE A-3 REARMING OPERATION USING COLUMN SUPPORT CONCEPT-MULTIPLE ACTIVITY CHART

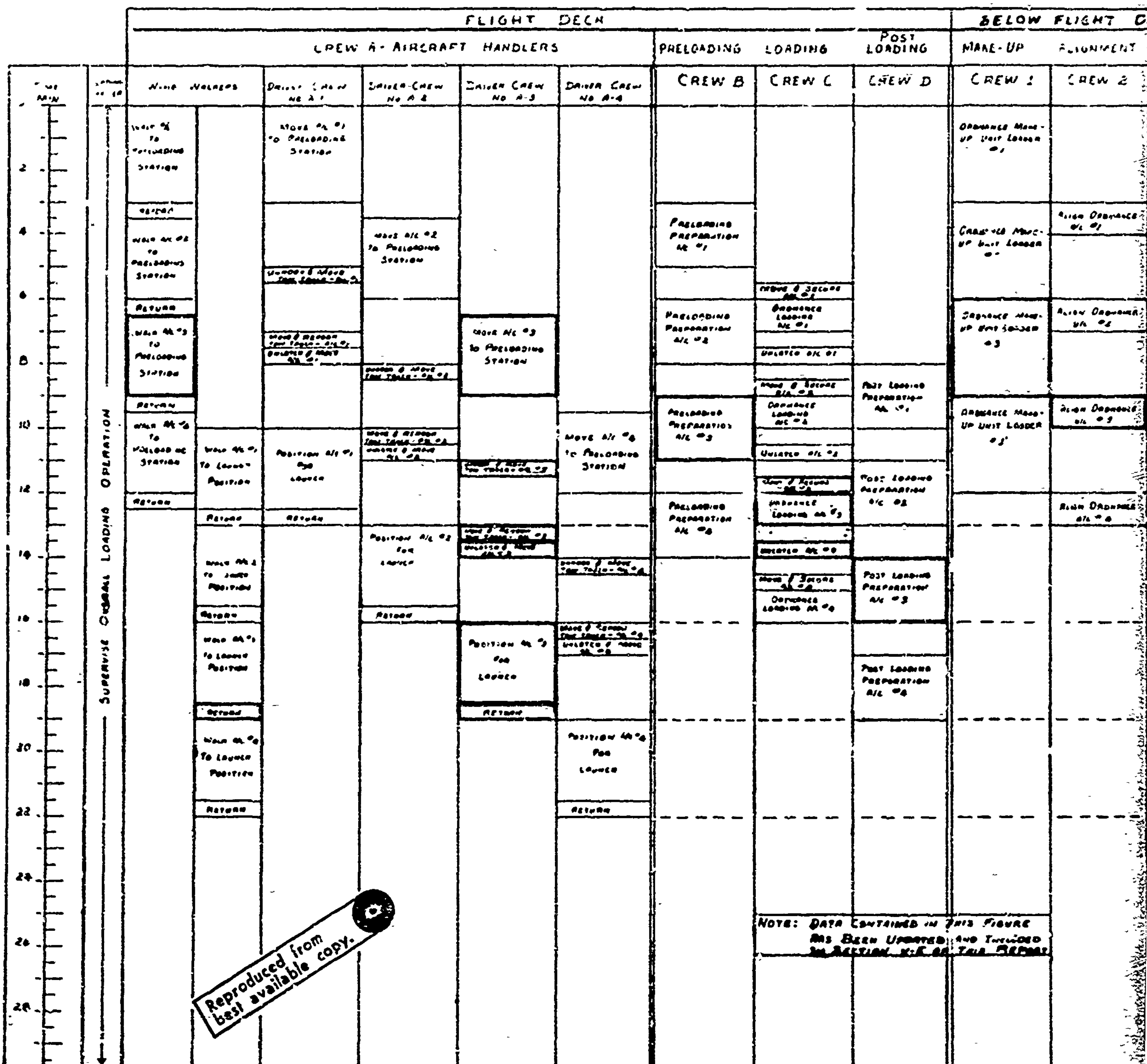


FIGURE A-4 — GUIDE RAIL SUPPORT OR EXTENDIBLE B[illegible]
MULTIPLE ACTIVITY CHART

B

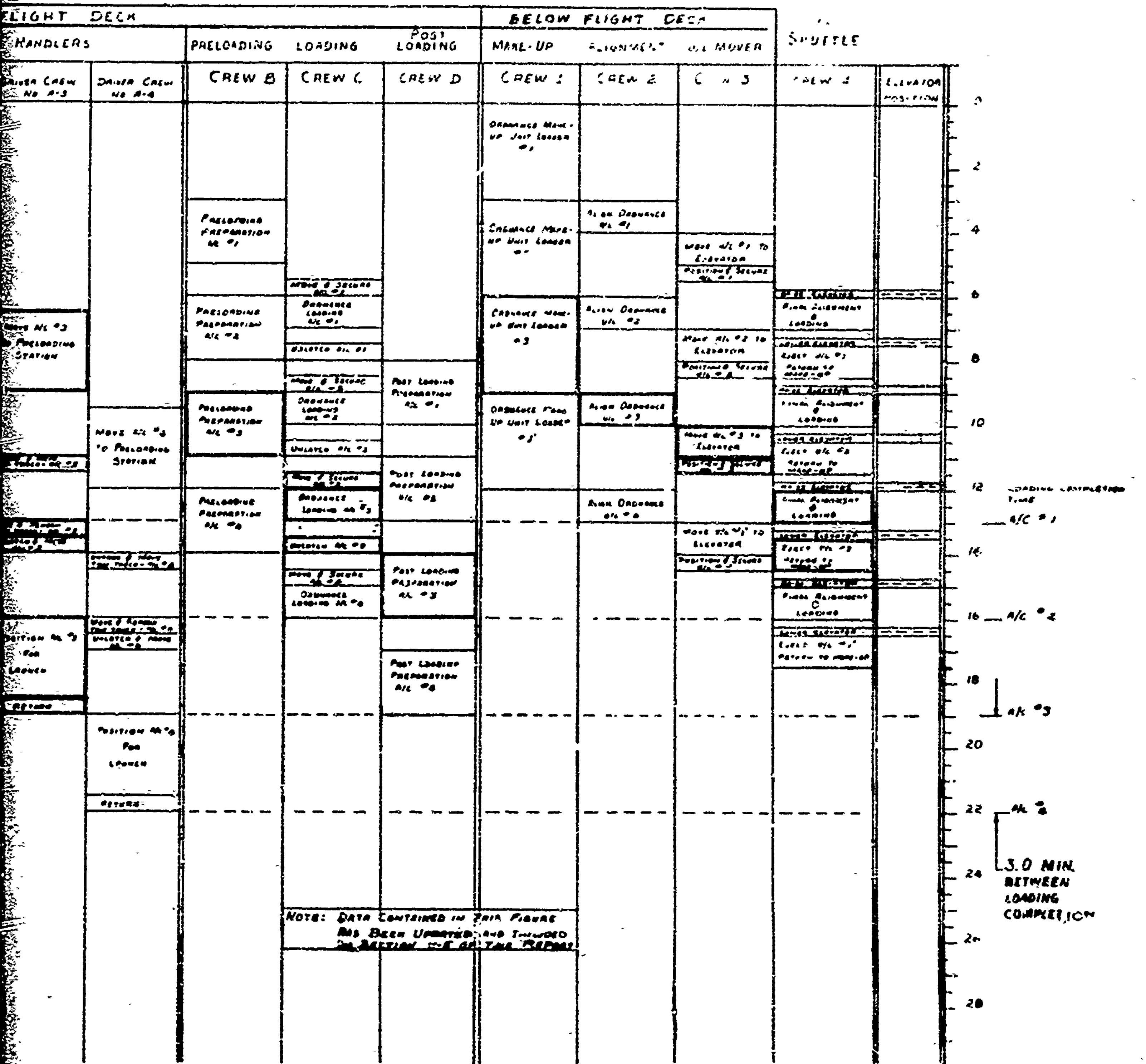


FIGURE A 4 — GUIDE RAIL SUPPORT OR EXTENDIBLE BEAM AND BRIDGE SUPPORT OPERATION - MULTIPLE ACTIVITY CHART

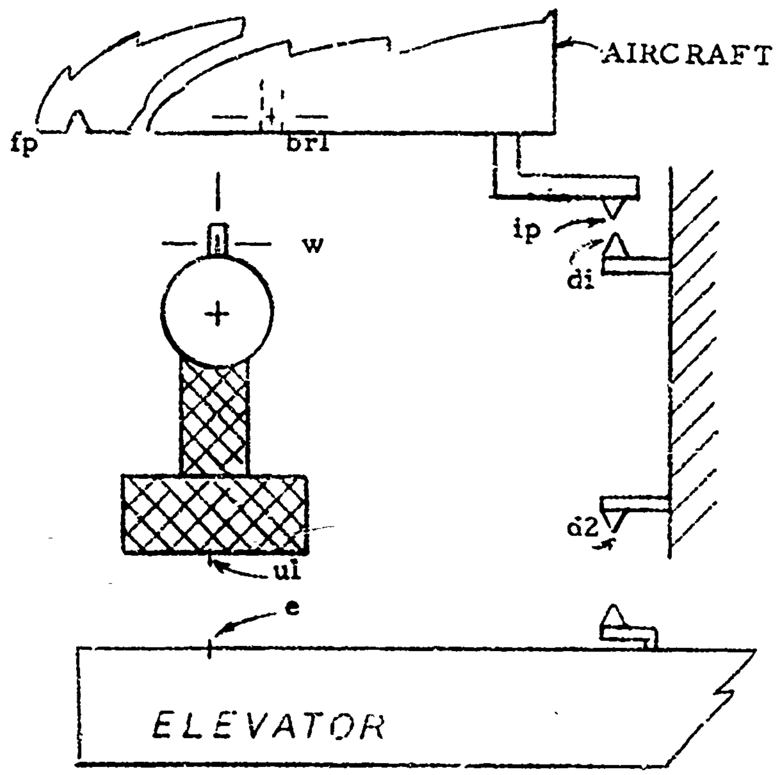
CONCEPT	CLASSIFICATION			ADJUSTABLE ELEMENT		TOLERENCE BUILD-UP STATIONS			
	MECHANICAL FORCED	SEMIAUTOMATIC	AUTOMATIC	AIRCRAFT	UNIT LOAD	QUANTITY	TYPE	LOW FRICTION PADS REQ'D	ELEVATOR REQ'D IN UP POSITION
B. FORCED ALIGNMENT AIRCRAFT BY RAISING ELEVATOR	X			MOBILE	FIXED	4	1, 2, 3, & 4	YES	YE
C. FORCED ALIGNMENT OF PALLET	X			FIXED	MOBILE	3	1, 2, & 3	YES	YE
G. THREE POINT ALIGNMENT OF AIRCRAFT	X			MOBILE	FIXED	3	1, 2, & 5	YES	YE
H. TWO POINT ALIGNMENT OF AIRCRAFT	X			MOBILE	FIXED	3	1, 2, & 5	YES	YE
J. ELEVATOR MOUNTED REFERENCE		X		FIXED	MOBILE		1, 2, & 5	NO	YE
E. ALIGNMENT OF A/C & ORDNANCE TO A COMMON DATUM		X		MOBILE	MOBILE	3	1, 2, & 5	YES	YE
A. TWO CONTROL POINT ALIGNMENT WITH MANUAL CONTROL		X		FIXED	MOBILE	2	1 & 2	NO	YE
D. AUTOMATIC ALIGNMENT PALLET TO AIRCRAFT			X	FIXED	MOBILE	2	1 & 2	NO	YE

FIGURE A-5 COMPARISON OF ALIGNMENT CONCE

B

TOLERENCE BUILD-UP STATIONS	LOW FRICTION PADS REQ'D	ELEVATOR REQ'D IN UP POSITION	UNIT LOADER REQ'D	EASY TO AUTOMATE	A/C DAMAGE POTENTIAL	REMARKS/NOTES
1, 2, 3, & 4	YES	YES	NO	YES	LOW	POSSIBILITY OF MISALIGNMENT TOLERENCE BUILD-UP
1, 2, & 3	YES	YES	YES	YES	LOW	
1, 2, & 5	YES	YES	YES	NO	EXISTS	
1, 2, & 5	YES	YES	YES	NO	EXISTS	
1, 2, & 5	NO	YES	NO	YES	LOW	FINE/FINAL ADJUSTMENT OF U/L DOES NOT EXIST
1, 2, & 5	YES	YES	NO	YES	LOW	A VARIATION OF USING A COMMON DATUM ON CARRIER STRUCTURE EXISTS.
1 & 2	NO	YES	YES	YES	LOW	FINE ALIGNMENT OF A/C IS NOT CRITICAL.
1 & 2	NO	YES	YES	—	LOW	A BACK-UP NONAUTOMATED ALIGNMENT SYSTEM IS NEEDED. COMPLEX SYSTEM

...N OF ALIGNMENT CONCEPTS

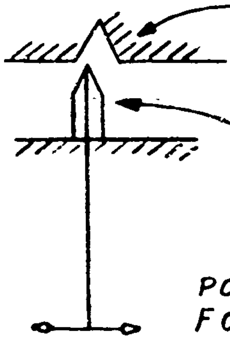
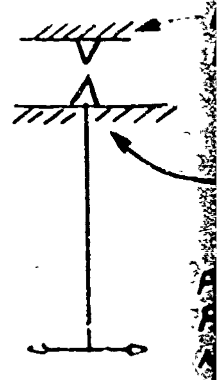


NOTE 1 - MAJOR STATIONS OF MISALIGNMENT

SYMBOL	STA. NO.	STATION
w/ul	1	WEAPON LUGS TO UNIT LOADER
brl/fp	2	A/C BOMB RACK LUGS TO FIXED POINT ON A/C
fp/ip	3	FIXED POINT ON A/C TO INDEXING POINT (SUPPORT PAD P/H)
ul/e	4	UNIT LOADER TO ELEVATOR
dl/d2	5	COMMON DATUM 1 TO COMMON DATUM 2.

FIGURE COMPARISON OF ALIGNMENT CONCEPTS (CONT'D)

FIGURE A-6 - COMPARISON OF GENERAL CONCEP
ALIGNING AIRCRAFT AND ORDNA

ITEM / CONCEPT	IMPORTANCE OF ITEM RATING (IR)	MECHANICAL/FORCED				SEMIA (MANUAL	
1. GENERAL CONCEPT							
EXAMPLE CONCEPTS IN REPORT HGS-R52-70		B, C, G & H				A, E	
	IR	RATING	IR x RATING	NOTES		RATING	IR
2. DESIGN ALIGNMENT CAPABILITY	2	1	2			3	
3. SYSTEM SIMPLICITY	3						
a. DESIGN SIMPLICITY		3	9			2	
b. OPERATIONAL SIMPLICITY		2	6			3	
c. SERVICEABILITY		3	9			3	
4. OPERATIONAL FLEXIBILITY	3						
a. NORMAL OPERATION		1	3			3	
b. BACK-UP ALIGNMENT CAPABILITY		1	3			3	
c. SYSTEM IMPROVEMENT POTENTIAL		2	6			3	
SUBTOTAL			38				

GENERAL CONCEPTS FOR
CRAFT AND ORDNANCE

CHD	8/5/71	DHO	1/2

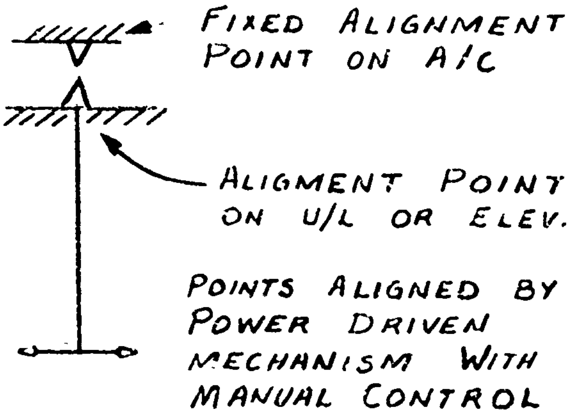
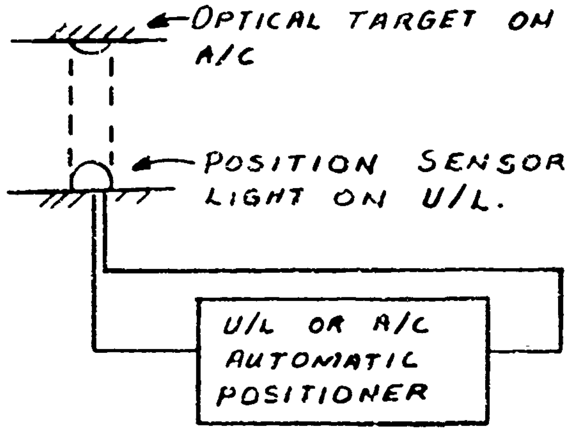
RCED	SEMIAUTOMATIC (MANUALLY CONTROLLED)			AUTOMATED/SENSOR CONTROLLED		
LIGNMENT N A/C OR RUCTURE NT PIN ELEV. SUPPORT NED BY INTO						
	A, E & J			D		
NOTES	RATING	IR x RATING	NOTES	RATING	IR x RATING	NOTES
	3	6		3	6	
	2	6		1	3	
	3	9		1	3	
	3	9		1	3	
	3	9		2	6	
	3	9		1	3	
	3	9		2	6	
		57			30	

FIGURE A6 - COMPARISON OF GENERAL CONCEPTS
ALIGNING AIRCRAFT AND ORDNANC

ITEM / CONCEPT	IR	MECHANICAL FORCED			SEMI A (MANUALLY	
		RATING	IR X RATING	NOTES	RATING	IR X
5. SAFETY/HUMAN ENGINEERING	3	3	9		3	
6. RELIABILITY & MAINTAINABILITY		3	9		2	
7. IMPACT ON ASSOCIATED SYSTEMS	2	2	4		2	
SUBTOTAL			22			1
TOTAL-CONCEPT RATING			60			7

IMPORTANCE OF ITEM RATING (IR)

3 VERY CRITICAL

2 IMPORTANT

1 NOT CRITICAL - FLEXIBLE

3

2

1

B

GENERAL CONCEPTS FOR
RAFT AND ORDNANCE

CHD 8/5/71 DKG 2/2

RCED	SEMIAUTOMATIC (MANUALLY CONTROLLED)			AUTOMATED / SENSOR CONTROLLED		
NOTES	RATING	IR X RATING	NOTES	RATING	IR X RATING	NOTES
	3	9		3	9	
	2	6		1	3	
	2	4		1	2	
		19			14	
		76			44	

ITEM RATING (IR)	CONCEPT RATING
	3 SUPERIOR CONCEPT
	2 EXCELLANT CONCEPT – ONLY MINOR REFINEMENTS REQUIRED
FLEXIBLE	1 WORKABLE BUT LIMITED CONCEPT

2. Baseline Alignment Concept

OBJECTIVE

To synthesize a baseline alignment system for the Unit Load Rearming System.

APPROACH

Select best elements of concepts defined in Chrysler Report HGS-R52-70.

ASSUME

An aircraft is preconfigured and ready for ordnance loading.

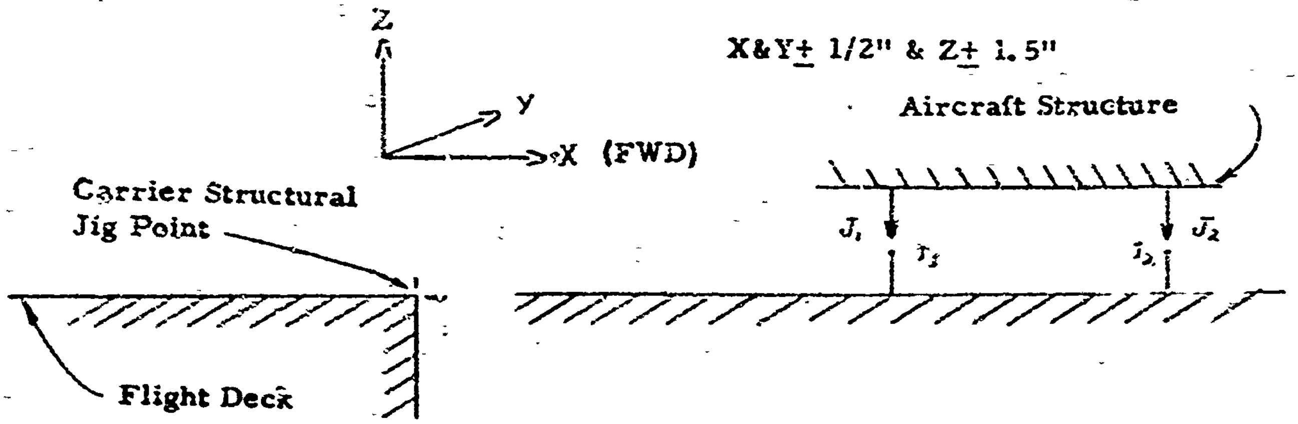
DEFINITION

1. Position & Secure Aircraft

Such that A/C structural jig points J_1 and J_2 coincide with on-deck index points I_1 and I_2 whose positions are accurately known X, Y, and Z, with respect to a carrier structural jig point.

A/C positioning goal with respect to I_1 & I_2

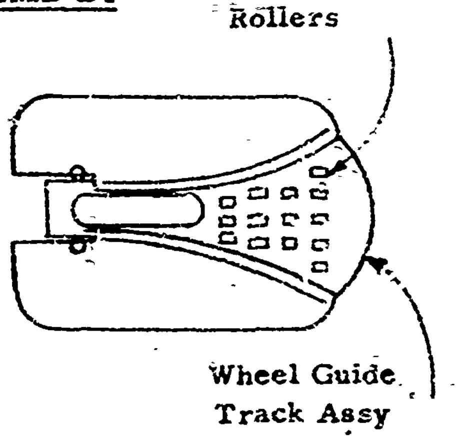
X&Y$\pm$ 1/2" & Z$\pm$ 1.5"



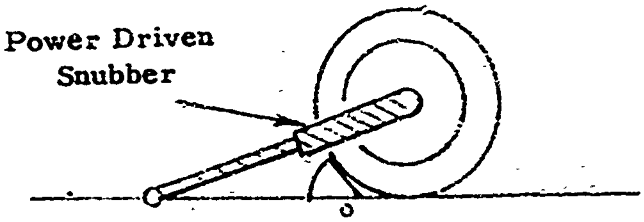
NOTE: Location of A/G Bomb Rack lugs is accurately known X, Y and Z with respect to A/C jig points J_2 and J_1.

POSITION & SECURING A/C IS ACCOMPLISHED BY

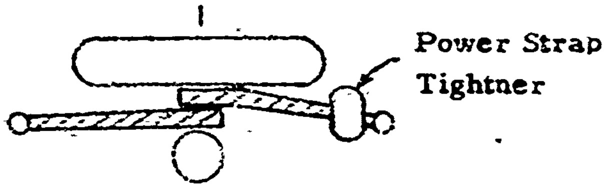
1. Using A/C wheel guide tracks for guiding front and main wheels (Y $\pm$ 1/2").

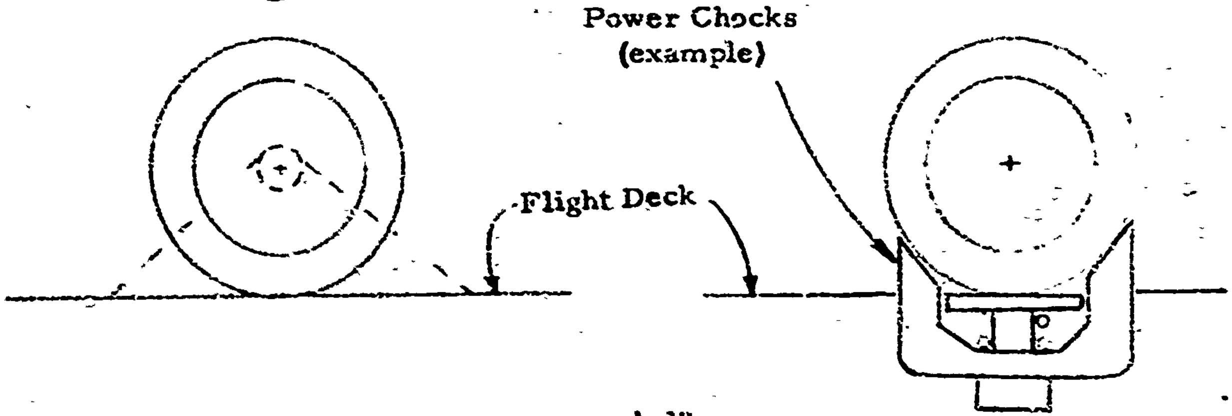


2. Snubbing front wheel into retractable chock (preindexed) (X $\pm$ 1", Z $\pm$ 1").



3. Securing main gear wheels using power strap or power chocks.

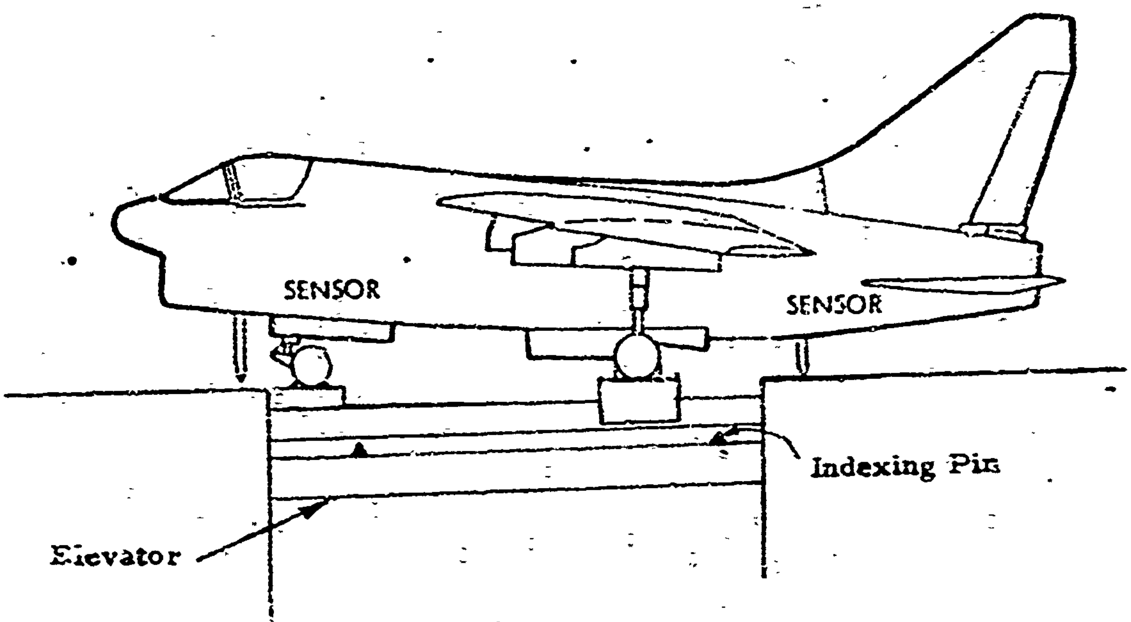




II. ALIGN & SECURE ELECATOR INDEX POINTS

Position two conical indexing pins P_1 & P_2 on elevator with respect to fixed structural jig points on flight deck I_1 & I_2.

Alignment of elevator indexing pins to I_1 & I_2 points is X, Y $\pm$ 0.02.



III. ALIGN WEAPON SUPPORT LUGS TO ORDNANCE PALLET

Weapon support lugs are positioned & secured in a pattern identical with Bomb Rack Lugs on A/C to be loaded.

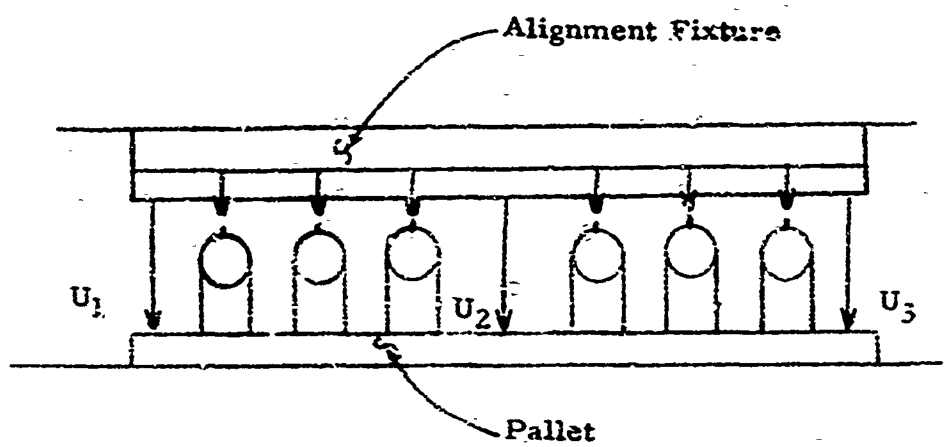
ACCOMPLISHED BY

Ordnance is loaded on and secured to weapon support fixtures.

The weapon support fixtures are located in the approximate locations with respect to the weapons pallet by manually positioning the respective lift table.

A mechanical aligument fuxture is lowered from overhead & matched with index points U_1, U_2 & U_3 on the ordnance pallet.

Top section of weapon support fixtures are adjusted X, Y & Z and in pitch, roll & yaw until weapon support lugs align with the corresponding alignment fixture points.



IV. ORDNANCE PALLET ALIGNED ON ELEVATOR

1. GENERAL

Metal wheel/ guide tracks on elevator are used for genrral positioning of ordnance pallet. Y $\pm$ 0.5" .

Ordnance pallet moves forward against general positioning pin X $\pm$ 1.0.

2. REFINED ALIGNMENT

Conical pins, aligned in section II, of this appendix, move upward on elevator engaging incones on ordnance pallet and force pallet into alignment.

V. FINAL ALIGNMENT VERFICATION & ADJUSTMENT

Elevator raises loaded and aligned weapons load until weapons support lugs are 2 to 3 inches below bomb rack lugs.

Verification is made that each weapon support lug is aligned with associated bomb rack lug within allowable envelope.

Indeividual weapon support fixtures are adjusted if and as necessary.

VI. LOADING

Weapons are raised until weapon support lugs lock into aircraft bomb rack lugs by:

1) Raising ordnance pallet with elevator or

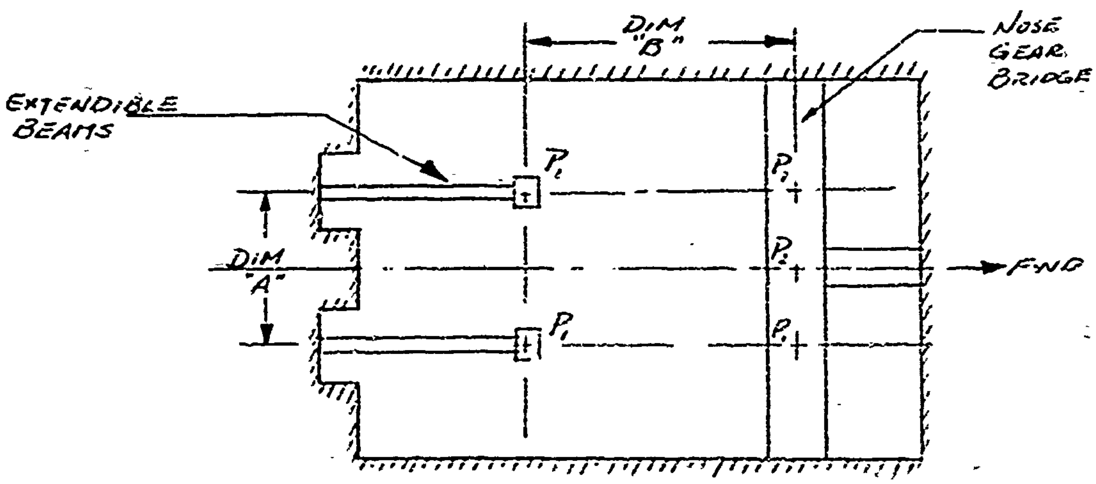
2) Raising individual weapon support fixtures.

A-II. AIRCRAFT SUPPORT CONCEPTS - PRELIMINARY MEMBER SELECTION AND WEIGHT COMPUTATIONS

The three aircraft support concepts were analyzed and a preliminary weight estimate made to enable a comparison based on added ship weight. These computations are based on the early rearming station concepts and dimensions[1] and were used only in selection of the baseline aircraft support concept. Shock loading has not been considered. However, the aircraft support concept selected as a baseline was analyzed for shock requirements and these computations are presented in Section A-III of the Appendix.

A. CONCEPT "A" (Extendible Beams & Bridge Support Concept)

A sketch of Concept A is shown below.



Refer to table A-1 and figure A-7 for A & B Dimensions.

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(1) The twenty-eight feet width of the rearming station was subsequently increased to thirty-two feet.

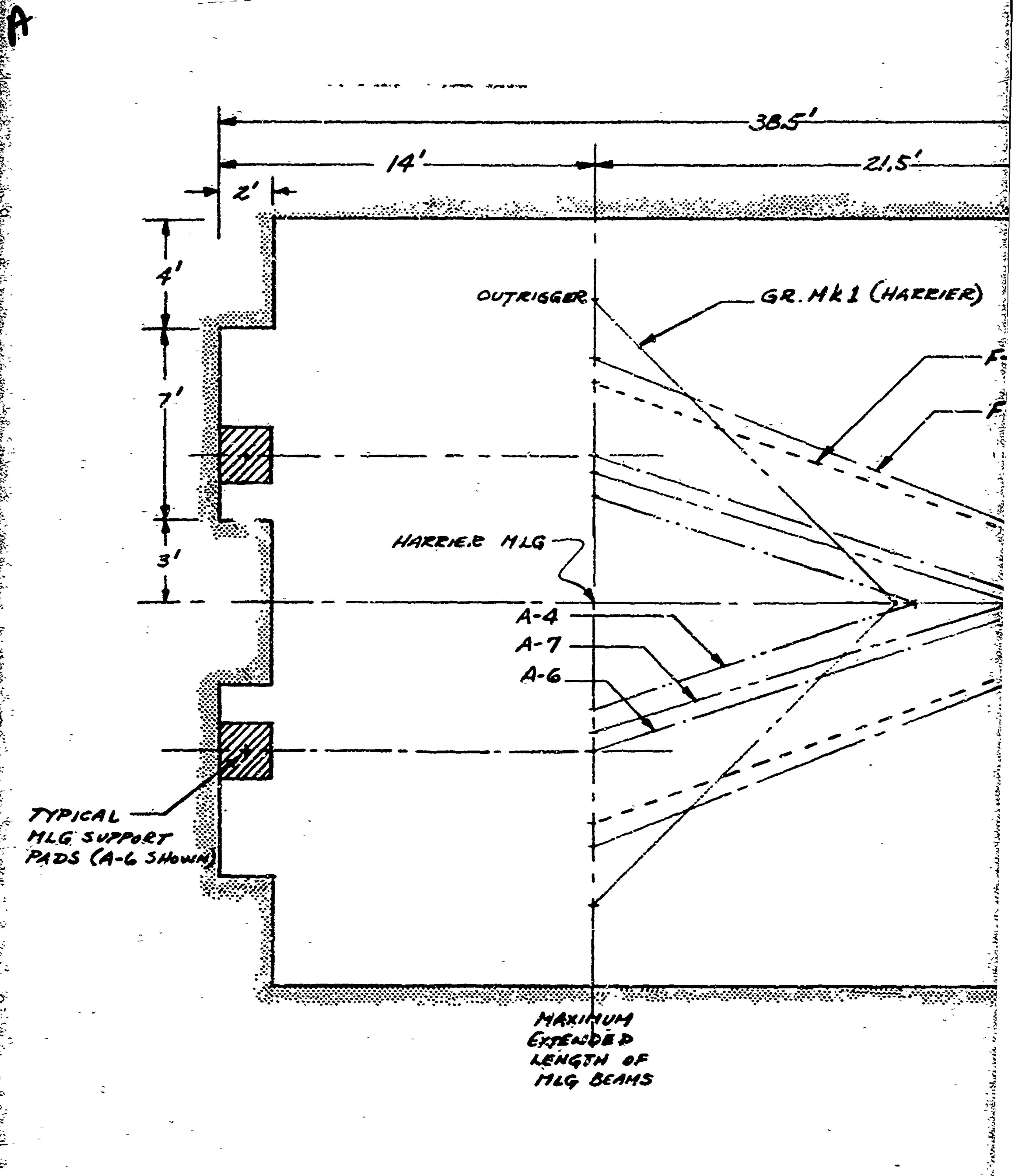
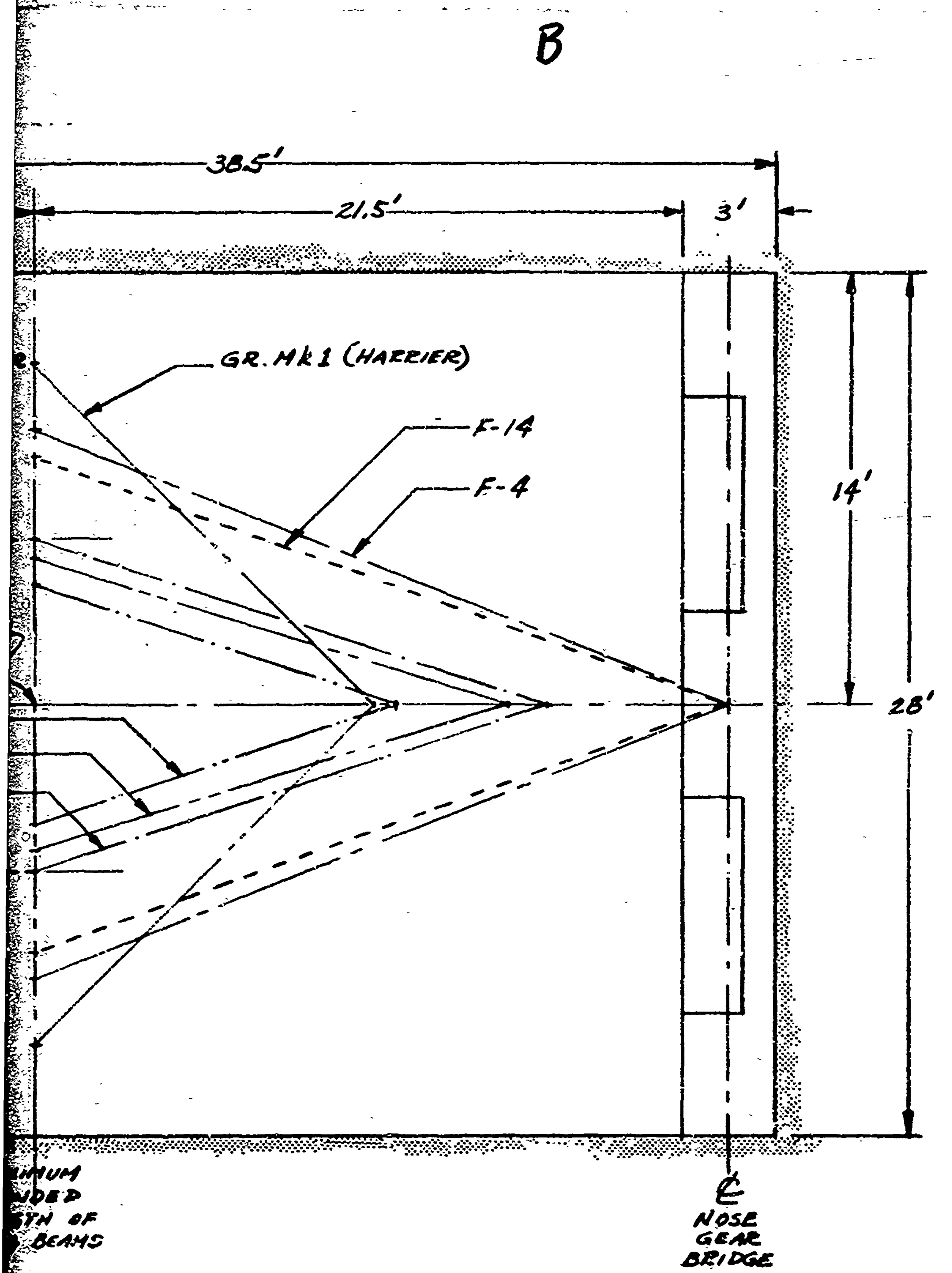


FIGURE A-7, CONCEPT "A" - LANDING G
SUPPORT POINTS

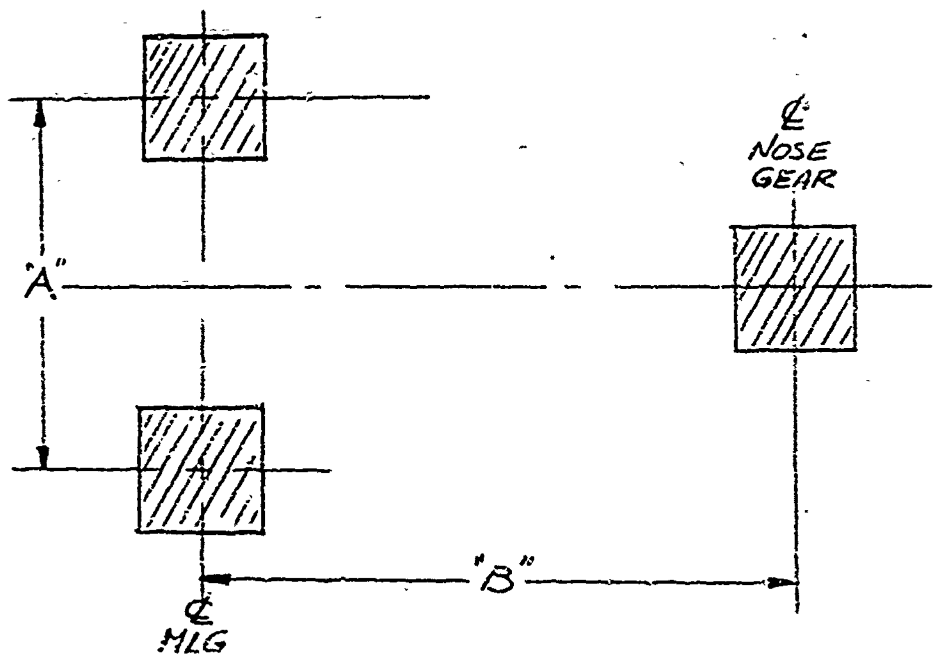


...URE A-7, CONCEPT "A" - LANDING GEAR SUPPORT POINTS

SCALE 1" = 4'

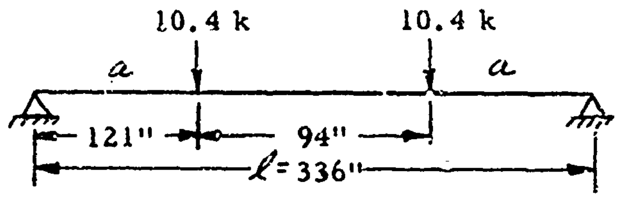
The maximum possible deflection of the main gear extendible beams occurs during A-6 aircraft loading, with a maximum T.O. weight of 60,626 lbs. For the nose gear bridge, the maximum moment will occur when the bridge is supporting the main gear. The moment depends on the wheel track and weight of the aircraft and are tabulated below.

Table A-1. Aircraft Weights and Landing Gear Dimensions



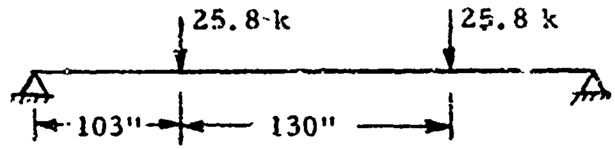
Aircraft	Dimension "A"	Dimension "B"	Max. T.O. Weight	Empty Weight
A-4	94" (7.8')	143" (11.9')	24,500	10,000
A-6	130" (10.8')	204" (17.0')	60,626	25,684
A-7	114" (9.5')	188" (15.7')	42,000	18,000
F-4	214" (17.8')	278" (23.2')	54,600	27,626
F-14	192" (16.0')	276" (23')	53,000	36,000

A-4



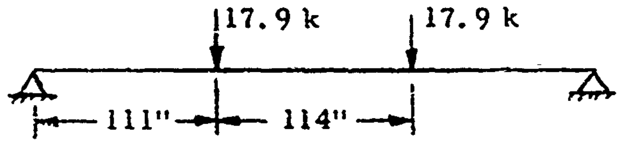
P = 85% (24,500)
P = 20.8 k

A-6



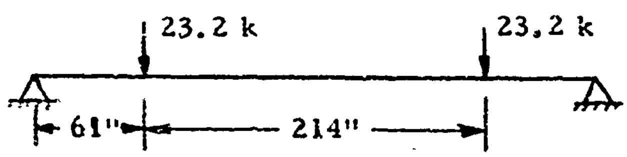
P = 85% (60,626)
P = 51.5 k

A-7



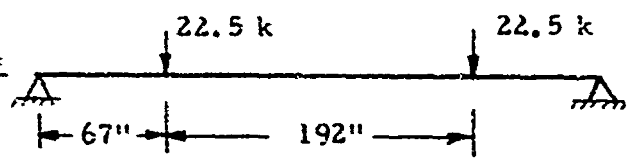
P = 85% (42,000)
P = 35.7 k

F-4



P = 85% (54,600)
P = 46.4k

F-14



P = 85% (53,000)
P = 45.0 k

$M = Pa$

$$\Delta_{max} = \frac{Pa}{24EI}(3\ell^2 - 4a^2)$$

For purposes of this analysis, assume that 85% of the a/c weight will be on the m. g. and the remaining 15% distributed to the nose gear.

$$\ell^2 = (336)^2 = 112,896 \text{ in}^2$$

$$E = 30 \times 10^6 \text{ psi}$$

$$\Delta_{max} = \frac{Pa}{24 \times 30 \times 10^6 (I)} (3 \times 112,896 - 4a^2)$$

$$\Delta_{max} = \frac{Pa}{720 \times 10^6 (I)} (338,668 - 4a^2), \quad M = Pa$$

A-4

$$\Delta_{max} = \frac{10.4\ (121)}{720 \times 10^3 (I)} \ (338,668 - 4\ (121)^2)$$

$$\Delta_{max} = \frac{489}{I}, \quad M_{max} = 10.4\ (121) = 1260 \text{ in-k}$$

A-6

$$\Delta_{max} = \frac{25.8\ (103)}{720 \times 10^3 (I)} \ (338,668 - 4\ (103)^2)$$

$$\Delta_{max} = \frac{1094}{I}, \quad M_{max} = 25.8\ (103) = 2660 \text{ in-k}$$

A-7

$$\Delta_{max} = \frac{17.9\ (111)}{720 \times 10^3 (I)} \ (338,668 - 4\ (111)^2)$$

$$\Delta_{max} = \frac{800}{I}, \quad M_{max} = 17.9\ (111) = 1985 \text{ in-k}$$

F-4

$$\Delta_{max} = \frac{23.2\ (61)}{720 \times 10^3 (I)} \ (338,668 - 4\ (61)^2)$$

$$\Delta_{max} = \frac{636}{I}, \quad M_{max} = 23.2\ (61) = 1415 \text{ in-k}$$

F-14

$$\Delta_{max} = \frac{22.5\ (67)}{720 \times 10^3 (I)} \ (338,668 - 4\ (67)^2)$$

$$\Delta_{max} = \frac{672}{I}, \quad M_{max} = 22.5\ (67) = 1510 \text{ in-k}$$

Maximum deflection is for A-6 loading.

$$\Delta_{max} = \frac{1094}{I} \text{ in}$$

$$\Delta_{max} = 2660 \text{ in-k}$$

Assume a maximum allowable deflection of 1/2" for the nose gear bridge.

Then,

$$I_{req'd} = \frac{1094}{\Delta} = \frac{1094}{0.5} = 2188 \text{ in}^2$$

Assume a 24" WF for weight and stress purposes.

$$S_{req'd} = \frac{I}{C} \quad \frac{2188 \text{ in}^4}{12 \text{ in}} = 182 \text{ in}^3$$

Use <u>24 WF 84</u>, $S_x = 196.3 \text{ in}^3$

$$f_b = \frac{M}{S} = \frac{2660 \text{ in-k}}{196.3} = 13.5 \text{ ksi}$$

$$F_b = 0.6\ (F_y) = 0.6\ (36) = 21.6 \text{ ksi (A-36 steel)}$$

$$MS = \frac{21.6}{13.5} - 1 = 0.6$$

For the main gear extendible beams, the maximum deflection and stress conditions are for an A-6 with gross weight of 60,626 lbs.

$P_1 = 25.8$ kips , $\ell = 14'$ (maximum)

$$\Delta_{max} = \frac{P\ell^3}{3EI} = \frac{25.8\ (168")^3}{3 \times 30 \times 10^3 (I)}$$

$\Delta_{max} = \frac{1360}{I}$, Limiting Δ_{max} to 1/2",

$I = 2720 \text{ in}^4$.

Assume a 24 WF Beam

$S_{req'd} = I/C = 2720/12 = 227 \text{ in}^3$

The most economical section with $S > 227$ is a 27 WF 94, $S = 242.8 \text{ in}^3$.

$S_{req'd} = 2720/13.5 = 201 \text{ in}^3$

Try 27 WF 94

$$f_b = \frac{M}{S_x} = \frac{25.8\ (168)}{242.8} = 17.9 \text{ ksi}$$

$$F_b = 0.6\ F_y = 0.6\ (36) = 21.6 \text{ ksi}$$

(Assuming ASTM A-36 Steel)

$$M.S. = \frac{21.6}{17.9} - 1 = 0.18$$

Use 27 WF 94, $S_x = 242.8$

Weight Estimates:

Total length of main gear beams will be assumed as 14' + 6' = 20' to provide for attaching beams.

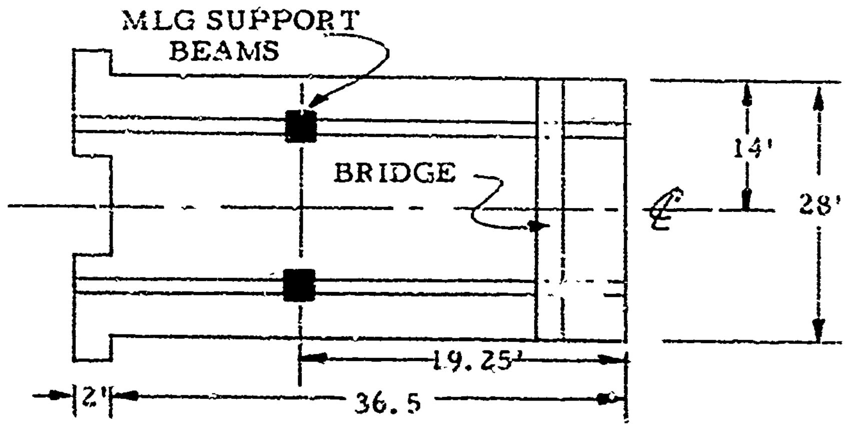
Main gear beams: 2 x 20' x 94 ppf = 3760#

Nose gear bridge: 28' x 84 ppf = 2352#

Total = 3760 + 2352 = 6112#

B. CONCEPT "B" (Guide Rail Support Concept)

The dimensions of the main gear beams and nose gear bridge are shown in figure A-8 and the sketch below.



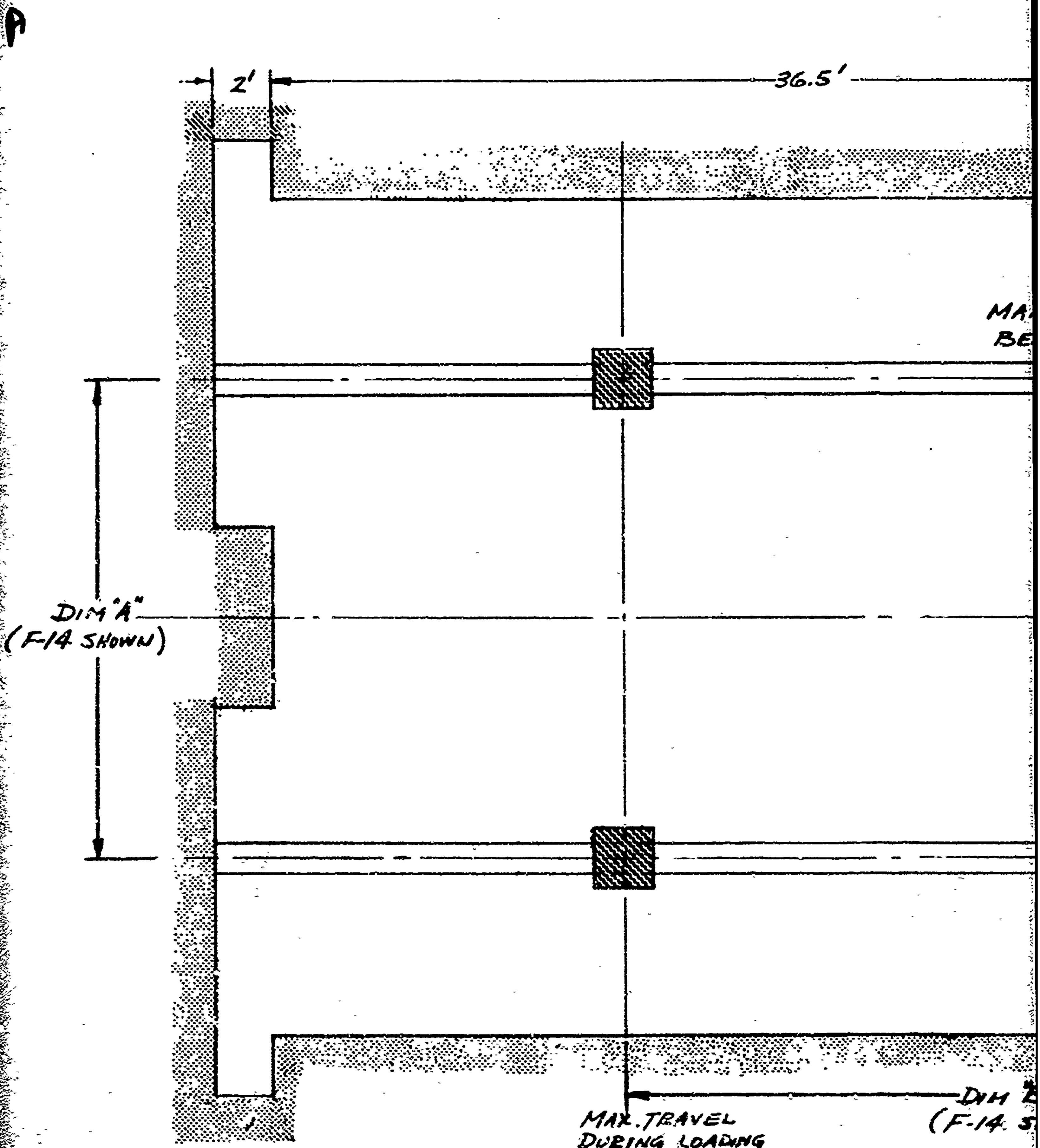


FIGURE A-8, CONCEPT "B". LA
SUPPORT PO

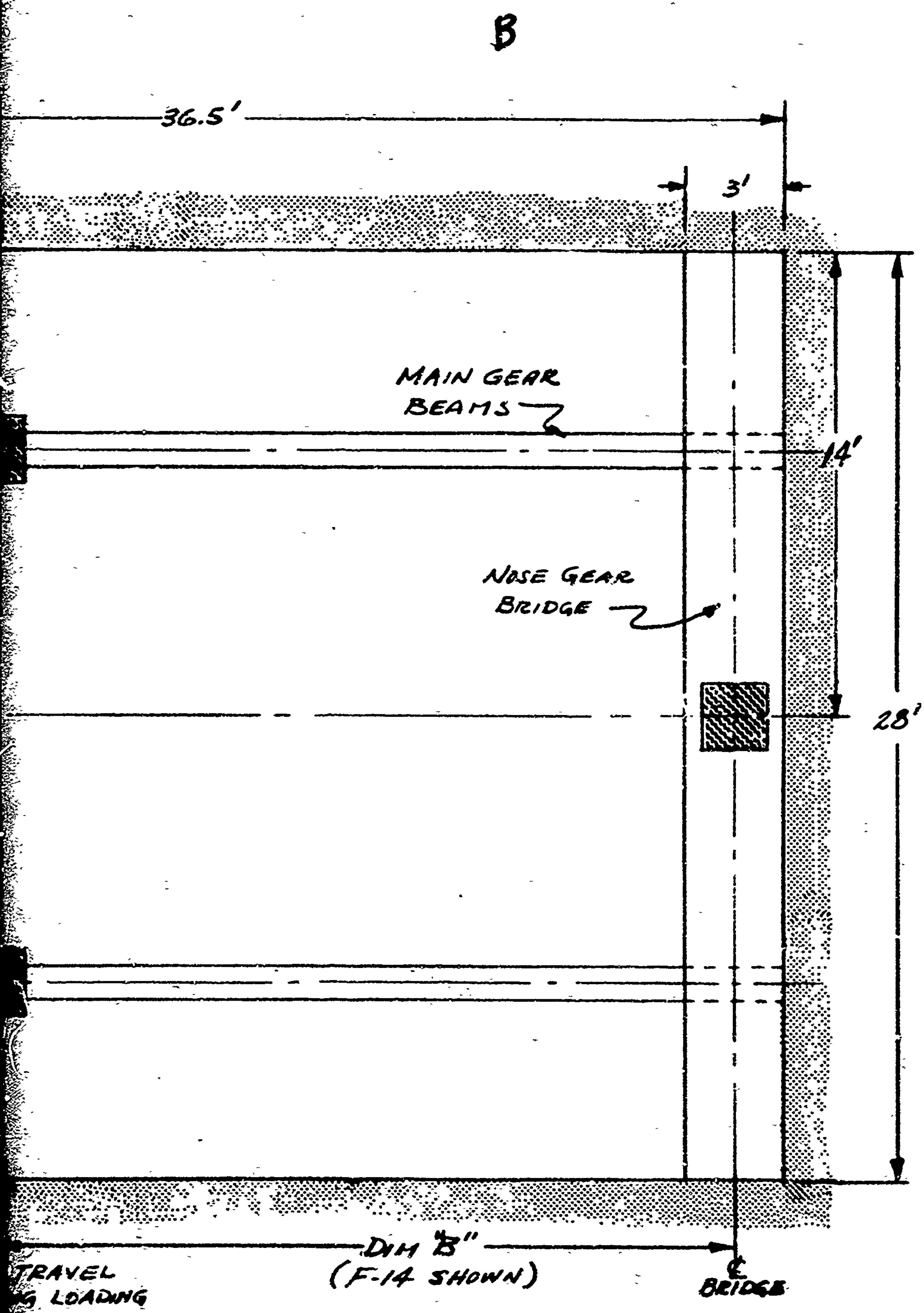


FIGURE A-8, CONCEPT "B" LANDING GEAR SUPPORT POINTS

The maximum stress and deflection on the main gear support beams occur when the m.g. pads are at the center of the beams. Assume P_1 = 85% x 1/2 (max. t.o. weight), P_1 = .85 x 0.5 (60,626) = 25,750 lbs.

$$\Delta_{max} = \frac{P\ell^3}{48EI} = \frac{25.75^k (462)^3}{48 \times 30 \times 10^3 (I)}$$

$$\Delta_{max} = \frac{1765}{I}$$

Limit the beam deflection to 1/2" at the center, the required I = 1765 (2), I = 3530 in^4. Assuming a 24 WF Beam,

$$S_{req'd} = 3530/12 = 294 \text{ in}^3$$

Lightest section will be a 30 WF beam,

$$S_{req'd} = 3530/15 = 235 \text{ in}^3$$

Try 30 WF 99, S_x = 269.1 in^3

$$\Delta_{max} = \frac{P\ell}{4} = \frac{25.75 (462)}{4} = 2975 \text{ in-k}$$

$$f_b = \frac{M}{S_x} = \frac{2975}{269.1} = 11.05 \text{ ksi}$$

$F_b = 0.6\ F_y$, For ASTM A36 Steel, F_y = 36 ksi

F_b = 0.6 (36) = 21.6 ksi

<u>Use 30 WF 99</u>

Maximum load on the bridge will be the maximum nose gear load, which is approximately 15% of max t.o. weight.

P = 0.15 (60,626) = 9100 lbs

$$\Delta_{max} = \frac{P\ell^3}{48EI} = \frac{9.1\ (336)^2}{48 \times 30 \times 10^3 (I)}$$

$$\Delta_{max} = \frac{9.1\ (26.3)}{I} = \frac{239.5}{I}$$

For 1/2" max deflection at center of the bridge beam, $I = 479.0\ in^4$.

Try an 18" WF beam, $S_{req'd} = \frac{479}{9} = 53.4\ in^3$

The lightest section is a 16 WF 36,

$$S_{req'd} = \frac{479}{8} = 60\ in^3$$

Try 16 WF 40, $S_x = 64.4\ in^3$

$$M = \frac{P\ell}{4} = \frac{9.1\ (336)}{4} = 764.4 \text{ in-k}$$

$$f_b = \frac{M}{S} = \frac{764.4}{64.4} = 11.85 \text{ ksi}$$

$$F_b = 0.6\ F_y = 0.6\ (36)\ 21.6$$

Use 16 WF 40

Allow additional beam length for detailing attachme.. to deck.

Weight Calculations:

2 x 99#/ft x 40' = 7920 lbs

1 x 40#/ft x 30' = 1200 lbs

Total = 9120 lbs

C. CONCEPT "C" (Column Support Concept)

Aircraft support positions for this concept are shown in figure A-9.

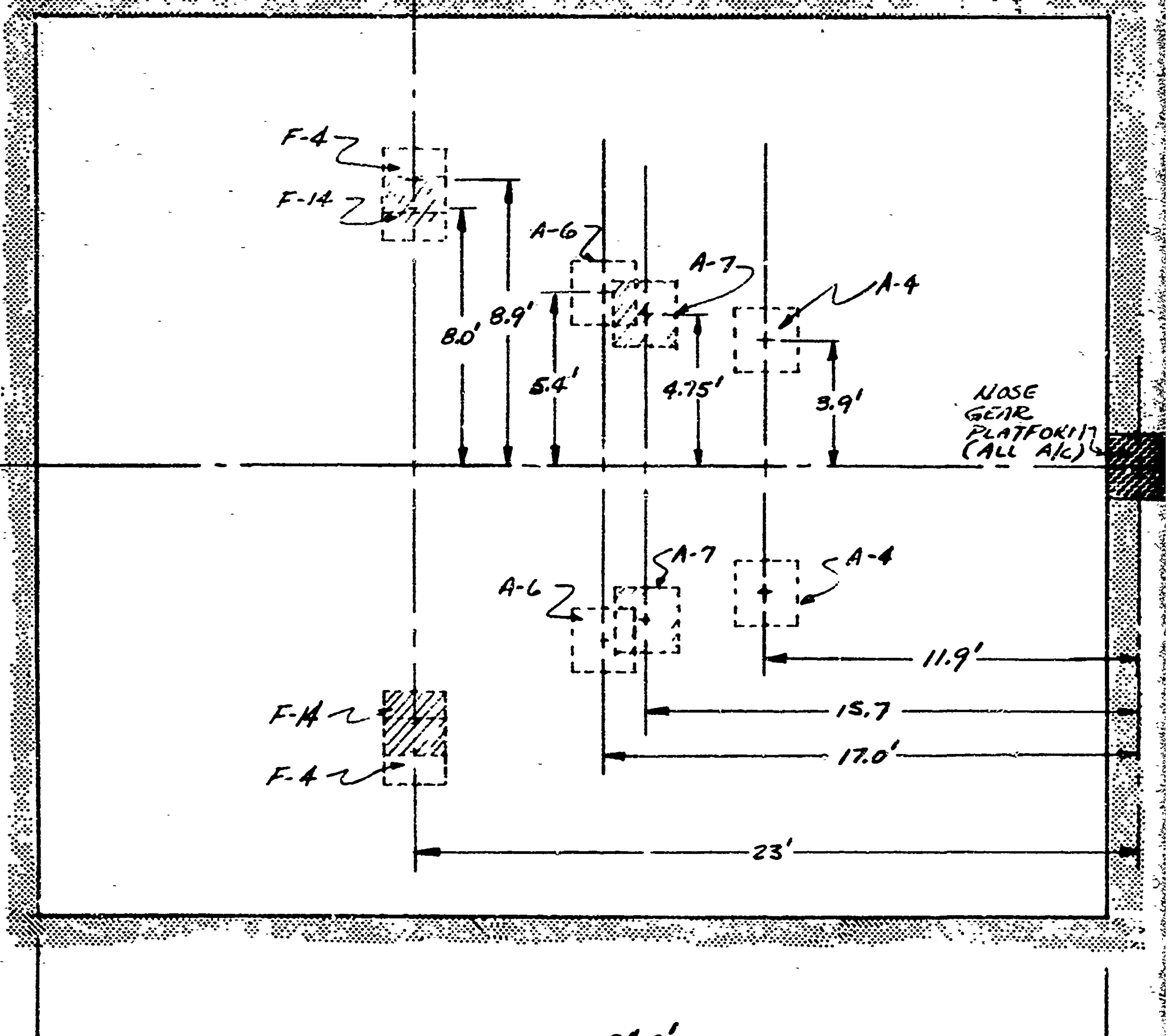
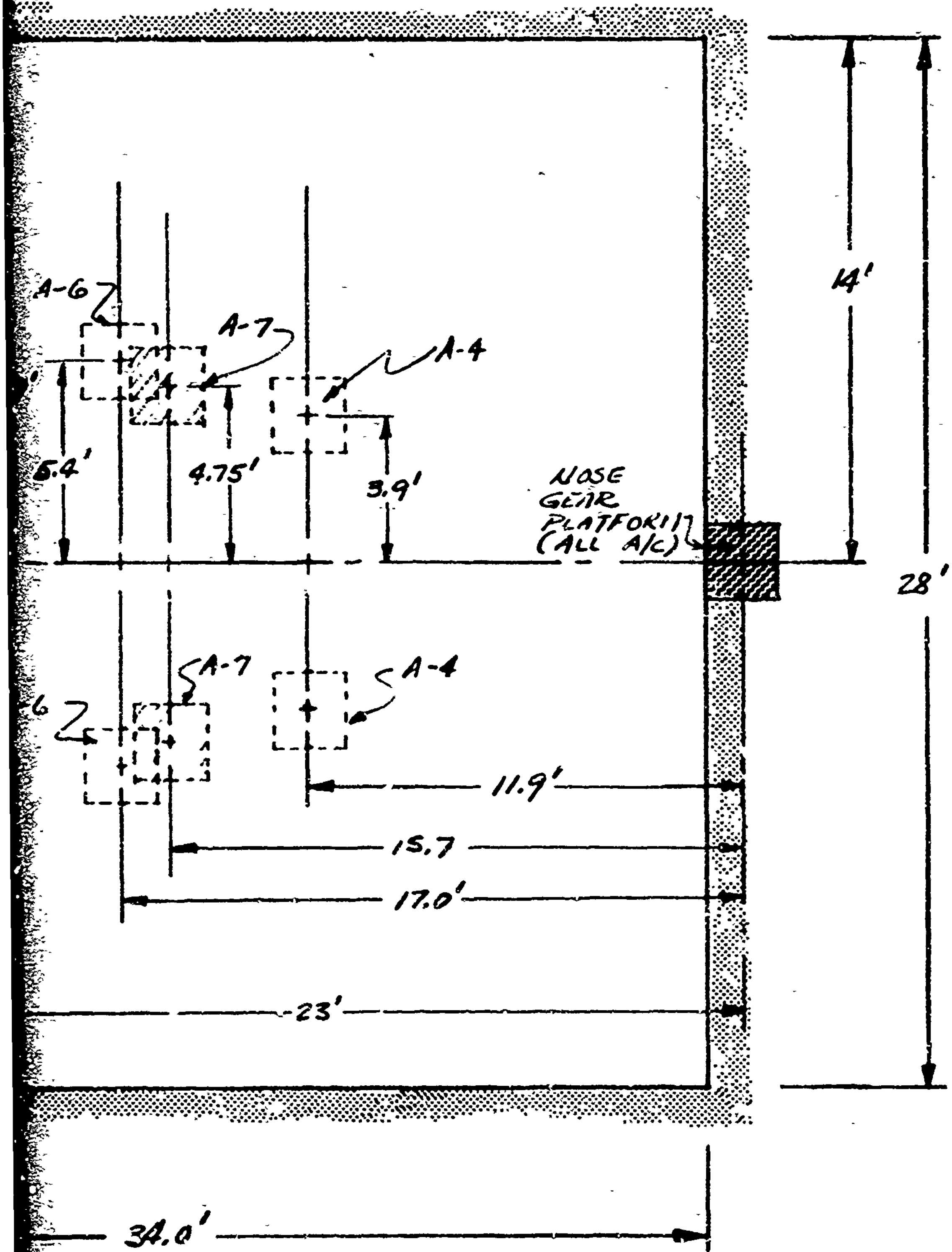


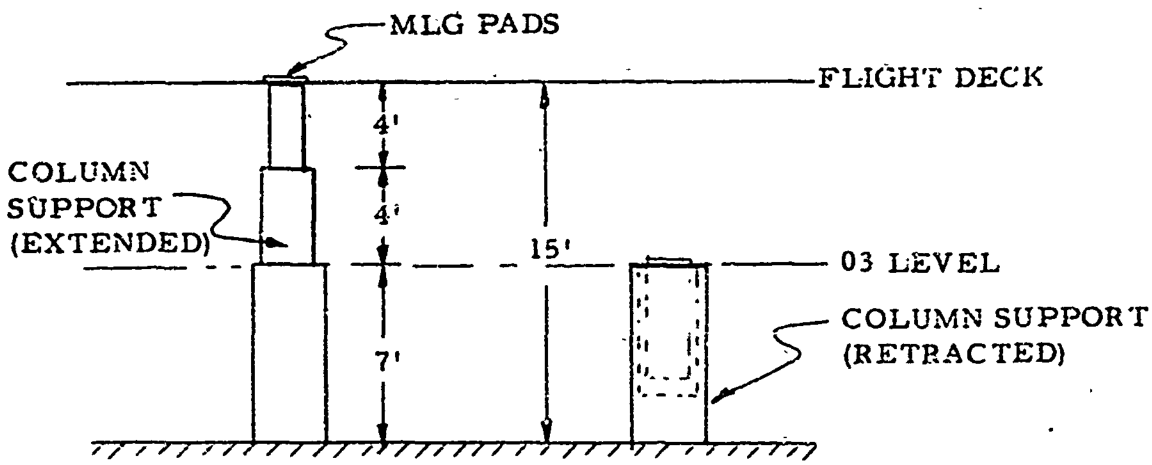
FIGURE A-9, CONCEPT "C" - LANDING GEAR SUPPORT POINTS

B



RE A-9, CONCEPT "C" - LANDING GEAR SUPPORT POINTS

SCALE 1"= 4'



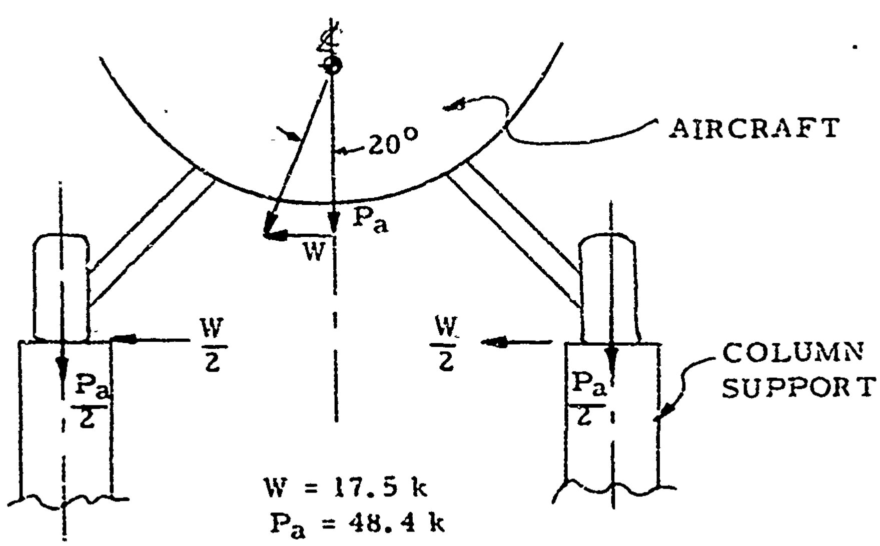
Assume a maximum column load = 85% of 1/2 the maximum take-off weight of the governing aircraft. (In this case, the A-6 aircraft.)

$$P_{max} = 0.85 \times 1/2\ (60,626\ \#) = 25.75 \text{ kips}$$

Assume a maximum list or roll angle during unit loading of $\pm 20^o$. The column loads are therefore equal to $P_{max} \sin 20^o$ and $P_{max} \cos 20^o$.

$$\frac{Pa}{2} = P_{max} \cos 20^o = 25.75\ (0.94) = 24.2 \text{ kips}$$

$$\frac{W}{2} = P_{max} \sin 20^o = 25,75\ (0.34) = 8.75 \text{ kips}$$



If a tubular section is used, the bending moment due to the transverse load will govern the design.

M @ base of column = 8.75^k (15' x 12) = 1575 in-k

$S_{req'd} = M/f_b$. Assuming A36 steel, f_b = 21.6 ksi

Try 12" Ø, 1.0" wall, A36 steel pipe (double extra strong)

$A = 36.91$ in^2, $r = 4.17$

$I = Ar^2 = 36.91\ (4.17)^2 = 642$ in^4

$S = I/C = 642/6 = 107$ in^3

$f_b = \dfrac{M}{S} = \dfrac{1575}{107} = 14.7$ ksi

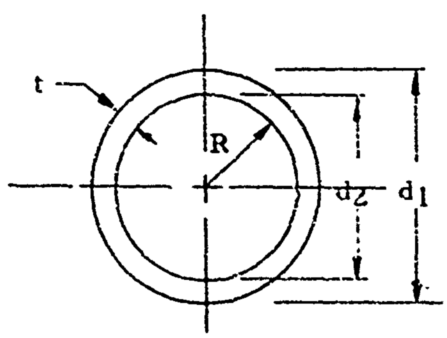
Use 12" Ø, 1.0" wall for last section, and for weight estimates, assume that the entire 15' length is 12" Ø.

15' x 2 x 125 ppf = 3750 lbs.

Try using 6061-T6 seamless aluminum tube for the 3 sections.

F_b = 24 ksi (Alcoa Aluminum Handbook, Specifications for 6061-T6, Appendix II, p. 42)

Largest commercially available extruded tube is a 12.75" o.d. with 1/2" wall



$d_1 = 12.75$

$d_2 = 11.75$

$\dfrac{R}{t} = \dfrac{5.875}{0.5} = 11.75$

$$S = \frac{\pi(d_1^4 - d_2^4)}{32\ d_1} = \frac{3.14\ (\overline{12.75}^4 - \overline{11.75}^4)}{32\ (12.75)}$$

$$S = \frac{3.14\ (26,430 - 19,600)}{32\ (12.75)} \quad \frac{21,450}{408} = 52.5\ in^3$$

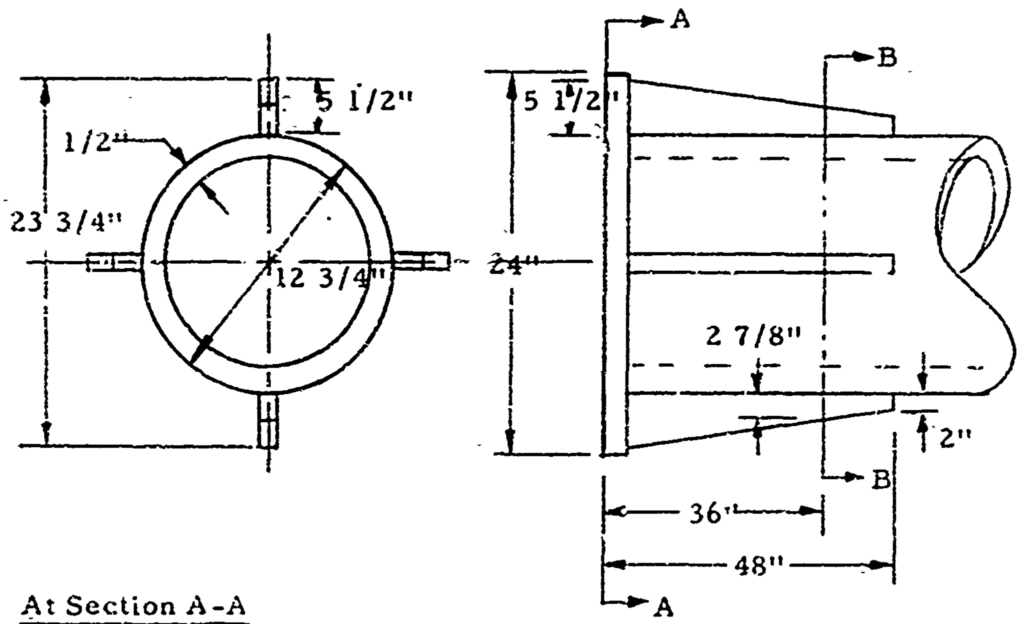
Allowable bending moment for 12 3/4" tube is

$M_{allow} = 52.5\ in^3 \times 24\ ksi = 1260\ in\text{-}k$

Beam length before allowable stress is exceeded is

$X = (1260\ in\text{-}k/12\ in/ft) \times 8.75\ k = 12\ feet$

Use gussets as shown below to stiffen the tube and to provide required section modulus.



At Section A-A

$M = 1575\ in\text{-}k$

$S_{req'd} = 1575\ in\text{-}k/24\ ksi = 65.6\ in^3$

$I_{tube} = S \times C = 52.5\ in^3 \times 12.75/2 = 335\ in^4$

$$I_{stiffners} = 2\ (Ad^2) = 2\ (1/2" \times 5\ 1/2")\left[\frac{23.75}{2} - \frac{5.5}{2}\right]^2$$

$I_{stiffeners} = 457\ in^4$

$I_{total} = I_{tube} + I_{stiffeners} = 335\ in^4 + 457\ in^4 = 792\ in^4$

$S = I/c = 792/11.875 = 66.7 \text{ in}^3$

Since the section modulus provided exceeds that required, a 12 3/4" tube with stiffener gussets is O.K. at Section A-A.

<u>At Section B-B</u>

$M = 8.75 \text{ k} \times 12 \text{ ft} \times 12 \text{ in/ft} = 1260 \text{ in-k}$

$S_{req'd} = 1260 \text{ in-k}/24 \text{ ksi} = 52.5 \text{ in}^3$

$I_{tube} = 335 \text{ in}^4$

$I_{stiffeners} = 2\ (Ad^2) = 2\ (1/2 \times 2\ 7/8") \left[\frac{18.5}{2} - \frac{2.875}{2}\right]^2$

$I_{stiffeners} = 2.875\ (61) = 175 \text{ in}^4$

$I_{total} = 335 + 175 = 510 \text{ in}^4$

$S = 510/9.25 = 55.2 \text{ in}^3$

Since the section modulus provided exceeds the section modulus required, a 12 3/4" tube with stiffener-gussets is O.K. at Section B-B. Use 12 3/4" Ø extruded tube for last section. Since the tubes must telescope, use 11 3/4" for middle section and 10 3/4 for last section. All tube will be 1/2" thickness.

<u>Weight Estimate:</u>

12 3/4" O.D., 1/2" Wall, $A = \frac{\pi(d_1^2 - d_2^2)}{4}$

$A = 0.785\ (\overline{12.75}^2 - \overline{11.75}^2)$

$A = 0.785\ (24.5) = 19.25 \text{ in}^2$

$W = 1.175\ \#/\text{in}^2/\text{ft}\ (19.25 \text{ in}^2) = 23.2\ \#/\text{ft}.$

Assume total length of 15' is 12 3/4 Ø for purposes of weight estimates.

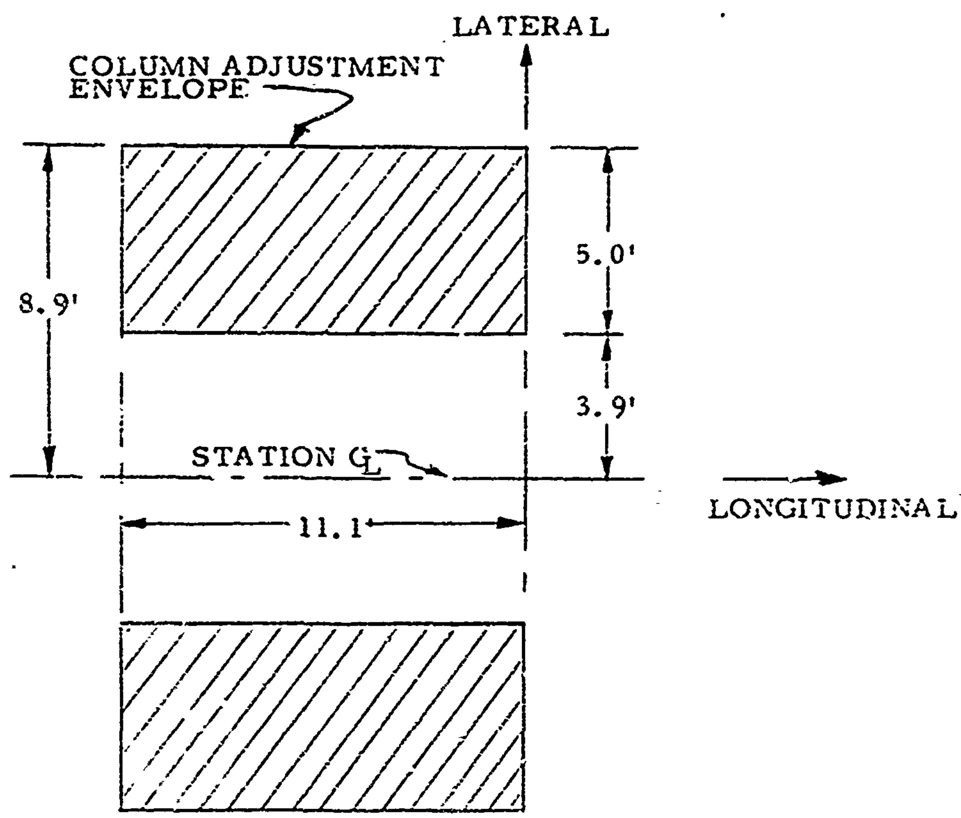
$15' \times 2 \times 23.2\ \#/\text{ft} = 696\ \#.$

Column adjustment to accommodate the A-4, A-6, A-7, F-4 and F-14 aircraft. (Refer to figure A-8.)

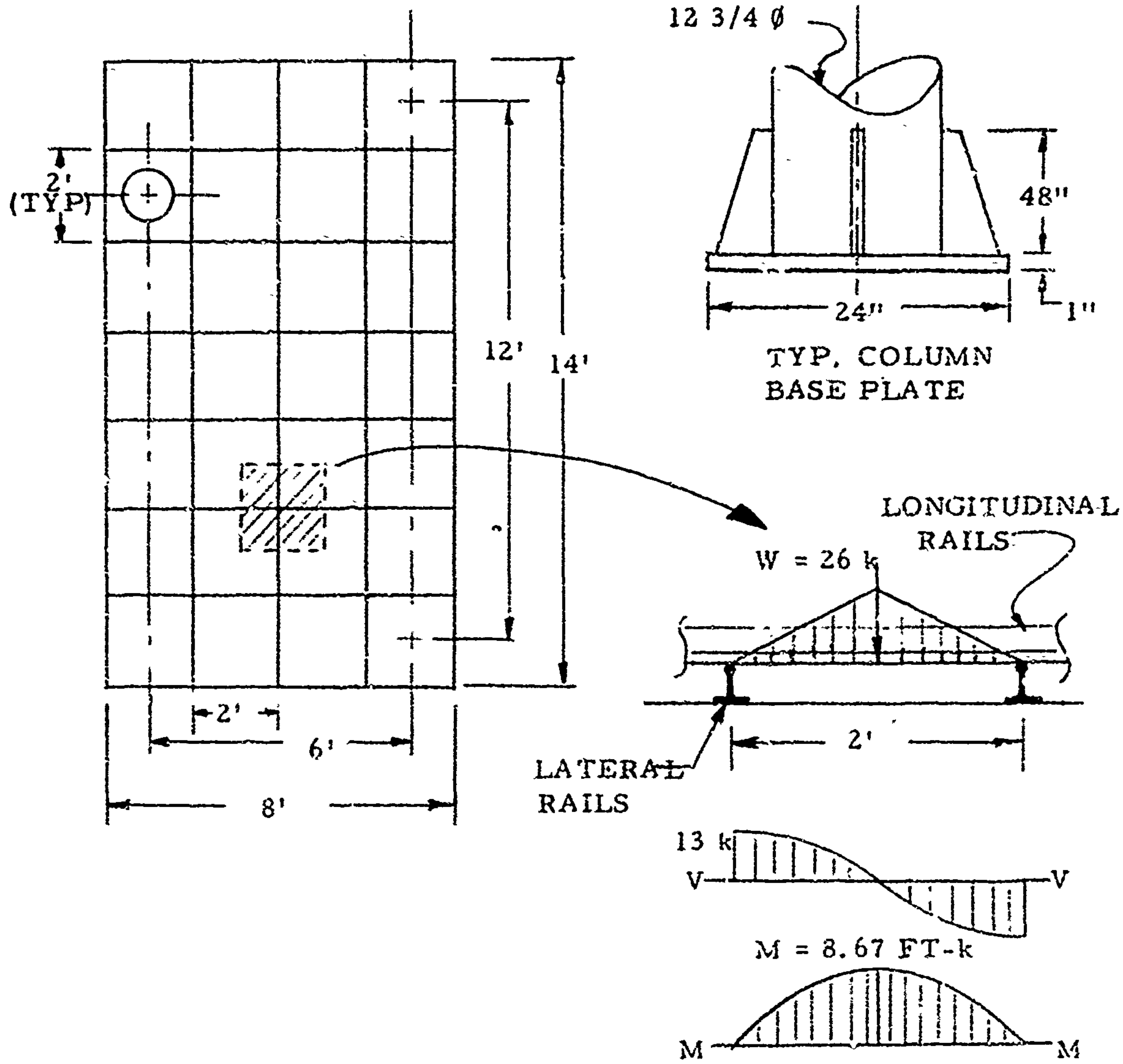
Longitudinal: 11.9' to 23' = 11.1'

Lateral: 3.9' to 8.9' = 5'

If the columns are movable within an envelope of these limits, the loading station will handle any aircraft with gear locations within these limits.



Base Pl. and rails



$$M_{max} = \frac{W\ell}{6} = 8.67 \text{ ft-k}$$

$$S_{req'd} = \frac{8.67 \text{ k} \times 12}{21.6 \text{ ksi}} = 4.82 \text{ in}^3$$

ASCE 60 provides a S = 6.6 in^3 (Ref. AISC Manual of Steel Construction)

Weight = 60 lbs/yard = 20 #/ft

Total = 5 rails x 14' + 8 rails x 8' = 70 + 64 = 134' x 20 #/ft = 2680 #

Base PL is 24" x 24" x 1" - wgt = 28.22 #/ft (Alcoa Handbook, p. 253)

Wgt = (2) (28.22 pounds/ft x 2 ft) = 113 #

Total Weight

Columns:	696 #
Base PL & Rails:	5473 # = 2680 (2) + 113
	6169 #

Check the column for buckling and local crippling. (Ref. Alcoa Structural Handbook, p. 110). Maximum unsupported length = 180". Assume 6061-T6 aluminum columns pinned at one end and free at the other, K = 2.0.

$E = 10.6 \times 10^6$ psi, F_y = yield stress = 35,000 psi.

Assume that the smallest tube cross section, a 10 3/4" Ø with 1/2" wall thickness, is used for the total column length.

$$A = 0.785\ (\overline{10.75}^2 - \overline{9.75}^2) = 0.785\ (115.5 - 98.7)$$

$$A = 16.8\ in^2$$

$$r = \sqrt{\frac{d_1^2 + d_2^2}{16}} = \sqrt{\frac{115.5 + 98.7}{16}} = \sqrt{\frac{214.2}{16}} = \sqrt{13.4}$$

$$r = 3.66\ in.$$

From "Alcoa Structural Handbook," p. 156, for curved plates and tubes in edge compression, the equivalent slenderless ratio is KL/r, where K is an end restraint factor, L is the unsupported length and r is the radius of gyration of the section.

$$\frac{KL}{r} = \frac{2.0\ (180)}{3.66} = 98 \qquad \text{(Failure as column)}$$

$$\frac{R}{t} = \frac{6.375}{0.5} = 12.75$$

$$\frac{KL}{r} = 4\sqrt{\frac{R}{t}}\left[1 + \frac{\sqrt{R/t}}{35}\right]$$

$$\frac{KL}{r} = 4\sqrt{12.75}\left[1 + \frac{\sqrt{12.75}}{35}\right] = 4\,(3.57)\left[1 + \frac{3.57}{35}\right]$$

$$\frac{KL}{r} = 15.7 \quad \text{(Failure by local buckling)}$$

Strength is controlled by column failure. From Alcoa St- uctural Handbook, p. 57, value of C = 63 for 6061-T6 extruded tube

$$\frac{KL}{r} > C \quad \therefore fc = \frac{102,000}{\left(\frac{KL}{r}\right)^2} \qquad \text{(Alcoa Structural Handbook, p. 111)}$$

where

fc = ultimate column stress, psi

$$fc = \frac{102,000}{(98)^2} = \frac{102,000}{9600} = 10,600 \text{ psi}$$

$$fa = \frac{P}{A} = \frac{25.75 \text{ k}}{16.8 \text{ in}^2} = 1530 \text{ psi (actual)}$$

A-III. AIRCRAFT SUPPORT CONCEPT "B"

The main gear support beams and nose gear bridge will be preliminarily sized in order to determine clearances and weights for the aircraft support system. The beam sizes for both the single pass and two-pass (baseline) rearming station concepts will be determined.

The given calculations are based on the length (38'-6") and width (32') of the single pass station. With the two-pass baseline station concept, the main gear beam is reduced to 28'-9" and the section modulus requirement will be greatly reduced. The nose gear bridge length will not change, consequently, the beam size will remain the same. The calculated sizes are used as preliminary sizes for both the single-pass and two-pass techniques of rearming.

The maximum conditions for the aircraft support beam design are the shock loading requirements outlined in "A Guide for Design of Shock Resistant Naval Equipment," NAVSHIPS-250-660-30. From a static analysis of the main gear support beams in Appendix A-I, it was determined that a 30 WF 99 beam, ASTM-A36 steel, would be required. A 16 WF 40 was selected for the nose gear bridge. With these beams as a starting point, beam sizes required for shock loadings will be determined.

In NAVSHIPS 250-660-30, the effect of shock loading is considered by determining a dynamic conversion factor (DCF) and applying this

factor to the static loads. The DCF is based on various parameters and allows for adjustments based on judgments concerning the yielding of the material, the weight of the system, and dynamic strength of t' materials, among other factors.

For a structure which can yield slightly without adverse affect, the resultant DCF is taken as 2/3 of the calculated DCF. The maximum static stress multiplied by the resultant DCF must then be less than the yield stress of the material.

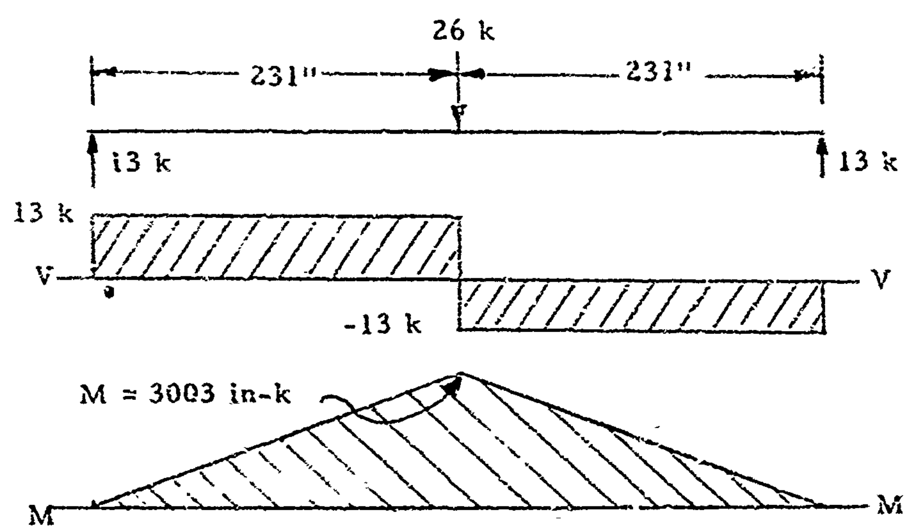
Each main gear support beam must be capable of carrying 1/2 the maximum gear load for the A-6 aircraft. It is assumed that 85% of the aircraft weight is distributed to the main gear and 15% to the nose gear.

Max beam load = 85% (1/2 x Max T.O. Wgt)

= 85% (1/2 x 60,626 lbs)

= 25,750 lbs Use 26 k

The shear and moment diagrams for this load are shown below.



It is assumed that the ends will be simply supported, the beams will be ASTM-A242, A440, or A441 structural steel with a yield point of 50 ksi, and a 30 WF 99 will be used for the initial iteration.

For 30 WF 99, $I = 3988.6 \text{ in}^4$, $E = 30 \times 10^6$ psi. From Appendix C, NAVSHIPS 250-660-30, the natural frequency of a simply supported beam with a concentrated mass is:

$$f = 3.13 \sqrt{\frac{EI}{q\left(W_i + \frac{17}{35} W_e\right)}}, \quad \text{where } q = \frac{EI}{k} \quad ; \quad k = \frac{W}{Z_{st}}$$

W_i = weight carried by the beam, lbs.

W_e = total weight of structural member having distributed weight, lbs

k = member stiffness, lbs/in

Z_{st} = static deflection, in

For the main gear support beams,

$W_i = 26$ k, $W_e = 99$ lbs/ft $\times$ 38.5 ft = 3812 lbs

$$q = \frac{EI}{k}, \qquad \frac{W}{Z_{st}} = \frac{W_i}{\frac{W_i \ell^3}{48\,EI}} = 48\,EI/\ell^3$$

$$q = \frac{EI}{48\,EI/\ell^3} = \ell^3/48$$

$$f = 3.13 \sqrt{\frac{30 \times 10^6 \times 3988.6}{\frac{(462)^3}{48}\left[26,000 + \frac{17}{35}(3812)\right]}}$$

f = 4.44 cps

Referring to Figure 2.10, NAVSHIPS 250-660-30, the resultant dynamic conversion factor for a total weight of 26,000 + 3820 = 29,820 lbs is estimated at 6 for a frequency of 5 cps. Assuming that slight yielding

can be tolerated, the modified DCF is 2/3 x DCF (from paragraph 2.4, ibid). Therefore, the DCF = 6 x 2/3 = 4, and the maximum dynamic load = 4 x 26 k = 104 k.

M_{max} = 52 k (231 in) = 12,012 in-k

F_y = yield stress = 50 ksi

$S_{req'd}$ = required Section Modulus = $\frac{M}{F_y}$

$S_{req'd} = \frac{12,012 \text{ in-k}}{50 \text{ ksi}} = 240^+ \text{ in}^3$

A 30 WF 99 provides a S_x = 269.1 in^3, therefore the beam meets the shock requirements. Use 30 WF 99 Main Gear Beams

For the nose gear bridge, P = 15% (60,626), P = 9100 lbs, ℓ = 32 ft = 384".

Assuming a 16 WF 40 beam, S_x = 64.4 in^3, I = 515.5 in^4; E = 30 x 10^6 psi, F_y = 50 ksi. For a simply supported beam

$$f = 3.13\sqrt{\frac{EI}{q\,(W_i + \frac{17}{35} W_e)}}$$

$q = \ell^3/48$

W_i = 9100 lbs

W_e = 40 lbs/ft x 32' = 1280 #

$$f = 3.13\sqrt{\frac{30 \times 10^6 \times 515.5}{\frac{(384)^3}{48}\left[9100 + \frac{17}{35}(1280)\right]}}$$

$$f = 3.13\sqrt{\frac{30 \times 10^6 \times 515.5}{\frac{52.62 \times 10^6}{48}\left[(9100 + 63)\right]}}$$

f = 3.9 cps

From Figure 2.10, NAVSHIPS 250-660-30, for total weight of 10,380 lbs. DCF = 9 for a frequency of 10 cps.

Tolerating slight yielding, DCF = 2/3 x 9 or DCF = 6.

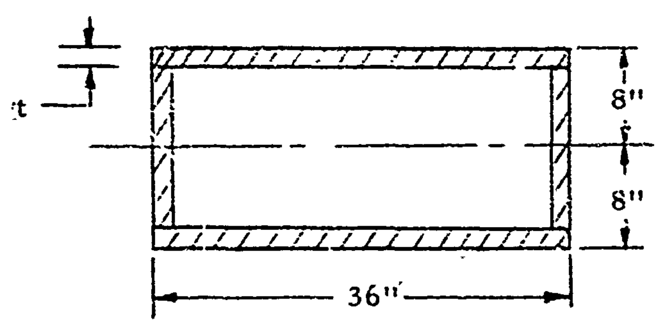
Dynamic load = 9100 lbs x 6 = 54,600 lbs

M = 54.6 k (192") = 10,480 in-k

$$S_{req'd} = \frac{M}{F_y} = \frac{10,480 \text{ in-k}}{50 \text{ ksi}} = 209^{+} \text{ in}^3$$

The 16 WF 40 beam provides a S_x = 64.4, therefore it will not meet the shock requirements. Determine the configuration of a box beam to provide the required section modulus.

A width of 36 inches has been allowed for the nose gear bridge. The depth must not exceed 16 inches in order to keep the beam depth from interfering with the weapons pallet. (A total depth of 48" has been assumed for the aircraft support system in the pallet and weapon support fixture design.) Determine the plate thickness for a box-section, 36 in wide x 16 in deep.



$$I_{req'd} = S_{req'd} (C) = 209^{+} \text{ in}^3 (8 \text{ in}) = 1672^{+} \text{ in}^4$$

$I \approx 2\,Ad^2$, $2\,A(8)^2 = 1672^{+}$, $2\,A(64) = 1672$

$A = 1672/128 = 13.06 \text{ in}^2$

$A = wt = 36 \text{ in } (t) = 13.06 \text{ in}^2$, $t = \frac{13.06}{36}$, $t = 0.36^{+}$ in

Use 1/2" PL for box-section, NOSE GEAR BRIDGE

$I = 2\ (36 \times 1/2)\ (8)^2 = 2304\ in^4$

Weight of top & bottom PL = 61.2 lbs/ft

Weight of side PL (assuming 1/2") ≐ 25.5 lbs/ft

Total weight = (61.2 + 25.5) 2 = 173.4 lbs/ft

W = 32 x 173.4 = 5548.8 lbs

Calculating the effect of adding beam weight and increasing the moment of inertia,

$$f = 3.13\sqrt{\frac{30 \times 10^6 \times 2304}{1.1 \times 10^6 \left[9100 + \frac{17}{35}(5550)\right]}}$$

$$f = 3.13\sqrt{\frac{30 \times 2304}{1.1 \times 11.800}} = 3.13\ \sqrt{5.32}$$

f = 7.2 , from Fig. 2.10 NAVSHIPS 250-660-30, DCF ≈ 8

Tolerating slight yielding, DCF = 2/3 x 8

DCF = 16/3.

$$P = 9100\ \#\left(\frac{16}{3}\right) = 48,600\ lbs$$

M = 48.6 k x 192" = 9,340 in-k

$$S_{req'd} = \frac{9,340\ in\text{-}k}{50\ ksi} = 187\ in^3$$

$$S \text{ provided by box beam} = \frac{I}{C} = \frac{2304}{8}$$

$S = 288\ in^3$

A-IV. WEAPONS PALLET AND WEAPONS SUPPORT FIXTURE MOVEMENT SYSTEM

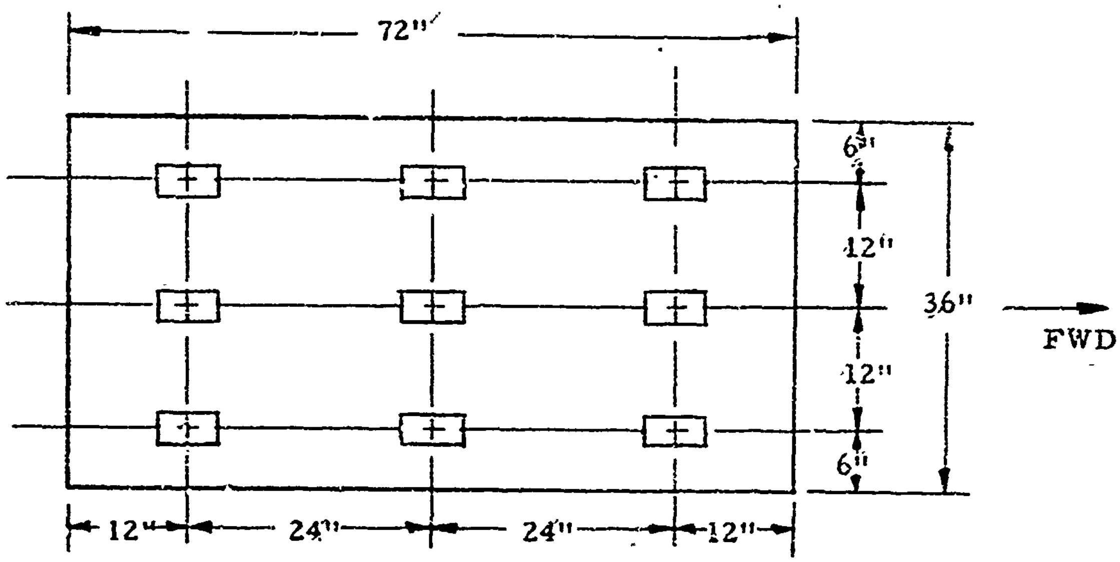
One concept for moving the weapons pallet on and off the rearming station elevator is a system of low friction ball bushings and rails as shown in figure 9. The ball bushing offers a coefficient of friction between 0.0011-.0019 (without lubrication) and the rails provide extreme rigidity. The weapon support fixtures will also be moved longitudinally and laterally by means of the ball bushing and rail system.

The primary purpose of sizing the rail system is to estimate weights and to establish geometric envelopes. The rail system has been sized for static and rolling loads <u>only</u>. Shock loads have <u>not</u> been included since a dynamic analysis of the rail system is beyond the scope of the present study. However, the rails and bushings have been purposely oversized to allow for shock influences.

For sizing the rails and bushings for the weapons support fixture, it was assumed that a maximum load of 5000 lbs will be placed on the lift table/weapon support fixture. Allowing 2000 lbs for the lift table and 1000 lbs for the weapon support fixture, the total load to be supported by the weapon support fixture rails is approximately 8000 lbs. The platform supporting the lift table/weapons support fixture is approximately 3' wide by 6' long. The rail spacing longitudinally has been assumed as 12", and a total of 9 ball bushings are assumed under each 3 x 6 platform. (See sketch below.) The ball bushings are envisioned

as being similar to Thompson Industries, Inc. products and design data from Thompson is used to size the bushings and rails.

The ball bushings will be positioned as shown on figure 10 and the sketch below.



Total Load = [illegible] # + 2000 # + 1000 # = 8000 #

Load/Bushing = 8000/9 = 888 #/bushing

Referring to figure 9, the maximum travel of the weapons lift table/support fixture is approximately 8 feet. Assume that the rearming station will be capable of loading one aircraft each 3 minutes and the normal strike plan will consist of rearming 21 aircraft per strike and 3 strikes per 24 hour-day. The travel life can now be computed based on these requirements.

$$\frac{21\ A/C}{Strike} \times \frac{3\ Strikes}{Day} = \frac{63\ A/C}{Day}$$

Each A/C rearming requires 2 cycles,

$$\frac{2 \text{ Cycles}}{\text{A/C}} \times \frac{63 \text{ A/C}}{\text{Day}} \times \frac{8 \text{ Ft}}{\text{Cycle}} \times \frac{12 \text{ in}}{\text{Ft}} = 12,096 \frac{\text{In}}{\text{Day}}$$

Assuming a minimum life of 2 years for the ball bushings,

$$730 \text{ days} \times 12,096 \frac{\text{in}}{\text{Day}} = 8.83 \text{ million-inches}$$

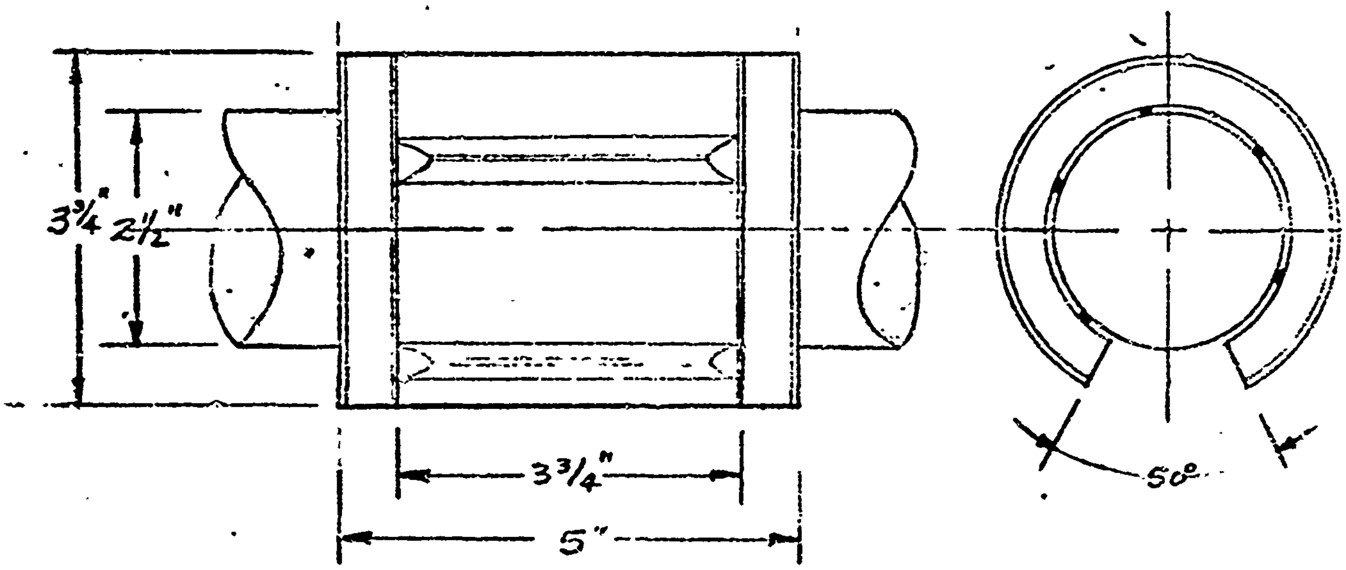
For a travel life of 8.83 million-inches and a shaft hardness of Rockwell 60C,

$K_L = 0.65$ and $K_H = 1.0$

$$\text{Rolling Load Capacity} = \frac{\text{Load Capacity Req'd}}{K_L \times K_H} = \frac{888 \text{ lbs}}{0.65 \times 1.0}$$

Rolling load capacity = 1365 #

A 2 1/2" diameter shaft and 3 3/4" diameter bearing provide a rolling load capacity of 1380 lbs.



The bearing and shaft shown above are typical of the type used on both the weapons pallet and the rearming station elevator.

In order to choose a preliminary size for the rearming station elevator support rails, a weight estimate for all equipment above the elevator rail level is used. In figure 12, the weight estimate is shown in graphical form for the individual equipment supported by the rearming station elevator rails. These rails will also extend from the make-up area to the elevator, a total distance of approximately 48 feet.

The weapons/skid weight estimate includes the heaviest ready service configuration of weapons which is 6-Mk 82/MER, AERO 73A, AERO 74A, AERO 75A Adapters and an AERO 21A skid with a total weight of 4575 lbs. To be conservative, a 5000 lb weight is assumed. The weapon support fixture weight is estimated at 1000 lbs and the lift table, 2000 lbs. The lift table weight is based on hardware presently available. It is a dual cylinder scissors-type lift table with a capacity of 8000 lbs and lift height of 62 inches.

The X-direction weapon support fixture rail weight estimate is based on previous calculations which indicated a 2 1/2" diameter shaft would be required. The 2 1/2" rails weigh 1.391 lbs/in or 16.7 lbs/ft. A total of 3 rails are required for each weapon support fixture, and a maximum of 4 wing station and 1 centerline station fixtures are required. The total length of each rail is approximately 13 feet.

Rail wgt = 5 x 3 x 13 feet x 16 7 lbs/ft = 3250 lbs.

A total of 9 bushings are used under each platform for a total of 45. A ball bushing for the 2 1/2" diameter shaft weighs 4.24 lbs.

Bushing weight = 4.24 x 45 = 191 lbs

Total wgt = 3250 + 191 = 3441 lbs.

Use 3500 lbs for rails and bushings.

The y-direction weapon support fixture rails (see figure 9 and 10) are assumed to have a 36-inch spacing. Since the weapon support fixtures will be moved laterally only when the type of aircraft to be loaded is changed, the amount of travel during a comparable 2-year period of operation for these rails will be much less than for the longitudinal (x-direction) rails. For purposes of this analysis, it will be assumed that the travel required will be less than 2 million-inches to provide a bushing life of two years.

For a maximum loading condition of the y-direction rails, assume the total weight of a weapon support fixture/platform is carried by three y-direction rails. Each y-direction rail has 3 bushings at each x-direction rail intersection, so that the total load is distributed to 9 bushings. The total load per bushing is $\frac{8000}{9}$ = 888 #. This is the same load as previously calculated for the x-direction rails; therefore, use the same rail and bushing size (2 1/2" diameter and 3 3/4" diameter). The weight of the y-direction rails and bushings are:

Total of 5 rails, each 28 feet long, and 75 bushings (one at each intersection of the x-direction and y-direction rails)

Total Rail Length = 5 x 28 ft = 140 ft.

Weight = 140 ft x 16.7 lbs/ft = 2340 lbs

Bushings = 75 x 4.24 lbs = 318 lbs

Total = 2340 + 318 = 2658 lbs.

Use 3000 lbs for y-direction

The weapons pallet platform will most likely be a trussed platform with beams to support the loads and lightweight plate sections to provide standing and working space. For purposes of this weight estimate, however, it will be assumed that the total platform is a steel deck 3/8" thick. The weight per square foot for 3/8" steel plate is 15.3 lbs. The area of the weapons pallet is 27 x 14 feet.

Weight = 27' x 14' x 15.3 lbs/ft = 5783.4 lbs.

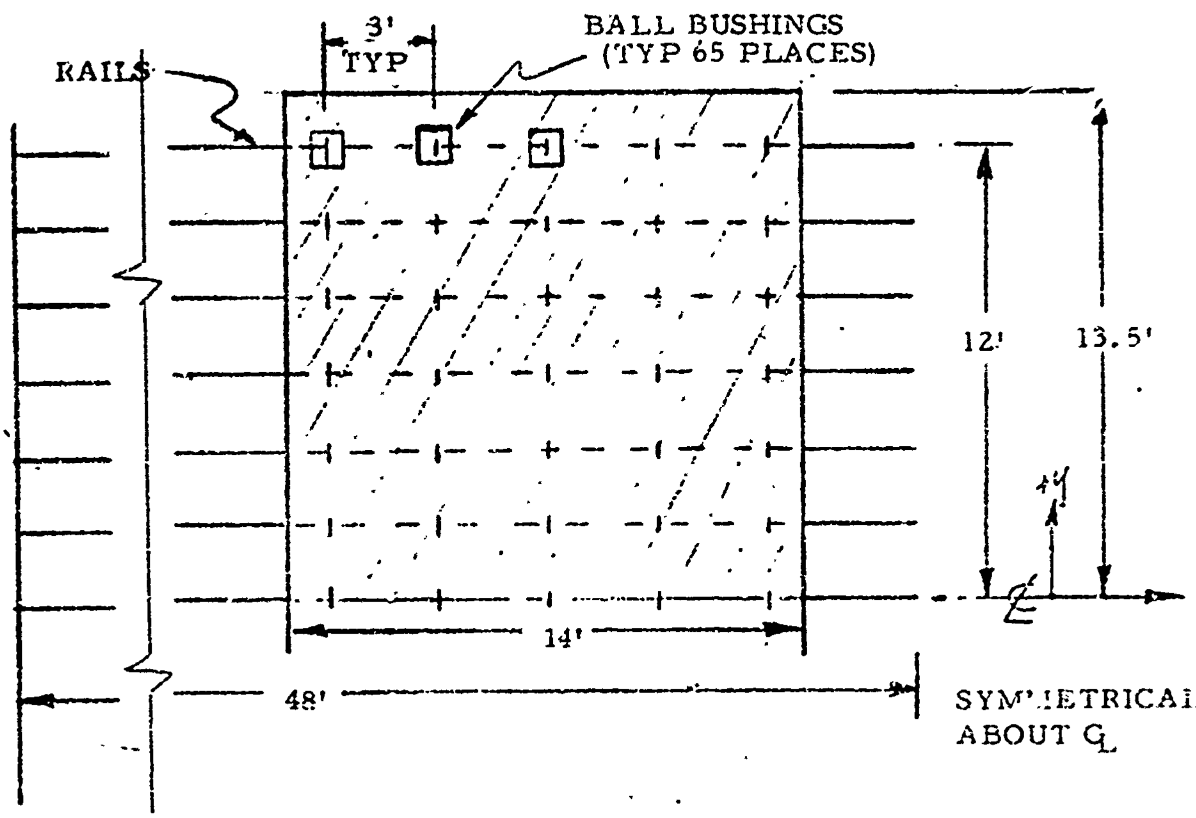
Use 6000 lbs for weapons pallet.

The rearming station elevator rails will now be sized based on the previous weight estimates, using the maximum load condition as the A-6 aircraft with all stations carrying 6-Mk-82/MER weapons. These figures are given in figure 12, and result in a total load of 52,000 lbs on the elevator support rails. The total distance traveled by the weapons pallet in moving from the weapons pallet make-up area to the rearming station elevator is approximately 48 feet. During each aircraft loading, the pallet must travel 96 feet. Using the same assumptions as before for the number of aircraft loaded, the travel life requirements for the elevator rails and bushings can be determined.

$$\frac{63\ \text{A/C}}{\text{Day}} \times \frac{96\ \text{feet}}{\text{A/C}} \times \frac{12\ \text{in}}{\text{ft}} = 72,576\ \frac{\text{in}}{\text{Day}}$$

Assuming a minimum life of 2 years for the ball bushings, the travel life required is: 730 days x 72,576 $\frac{\text{in}}{\text{day}}$ = 53 million inches

The load capacity required for each bushing is equal to the total load divided by the number of ball bushings. In the longitudinal direction, the rails are spaced on 2-foot centers, for a total of 13 rails, and each rail has 5 ball bushings spaced at 3-foot intervals along the x-direction of the weapons pallet, as shown in the sketch below.



With this spacing of rails and bushings, each bushing must carry

$$\frac{52,000 \text{ lbs}}{65} = 800 \text{ lbs.}$$

For the 53 million-inch travel life, and with Rockwell 60C rails, the load correction factor, K_L, as given in Thompson Industries design data, is equal to approximately 0.35. Also from Thompson Industries, the load correction factor, K_H, is equal to 1.0 for Rockwell 60C hardened shafts.

$$\text{Rolling load capacity} = \frac{\text{Load capacity req'd}}{K_L \times K_H}.$$

$$\text{Rolling load capacity} = \frac{800 \text{ lbs}}{0.35 \times 1.0} = 2280 \text{ lbs.}$$

The smallest bushing providing the rolling load capacity is a 4" inside x 6" outside diameter, a 4" diameter rail which has a rolling load capacity of 3800 lbs. The bushing weight is 17.25 lbs and the rail weight is 3.56 lbs/inch or 42.72 lbs/foot.

For weight estimates, use 65 - 6" O.D. bearings and the 2-foot rail spacing. The maximum rail length is approximately 64' (for single-pass rearming).

Rail weight: 12 rails x 64' x 42.72 lbs/ft = 35,500 lbs

Bushing Weight = 65 bushings x 17.25 lbs = 1120 lbs.

Total Weight = 36,620 lbs.

Note that the rail system has been sized for the extreme case, i.e., for single pass rearming, which results in the maximum distance from the make-up area to the rearming station elevator and for one make-up area at one level. For the station concepts using two weapons pallets and two make-up areas, the travel life of the rails and bushings should double.

As seen by the above weight estimates, the rearming station/make-up area rails account for the largest percentage of the total rail system weight. Therefore, a significant weight savings could be realized by using an alternate scheme for shuttling the weapons pallet from the make-up area to the rearming station elevator. One alternative is to use an air bearing to support the weapons pallet and two longitudinal beams along the edge of the rearming station to guide and restrain the pallet as it is moved from the make-up area to the elevator.

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